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## SOME FIELD AND LABORATORY STUDIES OF SOIL DRIFTING IN SASKATCHEWAN[1]

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The severe drought which Western Canada has experienced during recent years has intensified many of the problems incidental to agricultural practice in semi-arid regions; one of the most outstanding examples is that of wind-erosion or soil drifting, which has become a serious menace in many districts.

It is a known fact that soil drifting occurred during periods of drought in the early years of settlement in Manitoba and southeastern Saskatchewan. Since the breaking up of vast stretches of grass-land in western Saskatchewan and Alberta, the condition has become more widespread and severe whenever climatic factors have favored its occurrence. It is worthy of note that the problem of soil drifting was one of the important studies undertaken by the Royal Commission of Inquiry into Farming Conditions in Saskatchewan, 1921 (*7*). The problem has also been discussed in papers dealing with methods of control (*1*, *9*).

The Saskatchewan Soil Survey, which originated from a recommendation of the above commission, has published to date nine survey reports covering various areas of Saskatchewan (*2*). Reference is made in the reports to those soils found to be subject to drifting at the time the surveys were made. Briefly they were the very heavy soils such as heavy clays and clays and the very light soils such as sandy loams and sands. The medium textured soils were not subject to drifting, except those types of a distinctly silty nature, such as silt loams and silty clay loams.

### Field Observations

The soil survey field work during the past summer involved a general traverse of the zones and the main soil groups with a view to completing the reconnaissance survey map of the province. In addition to the main project, it was decided to make observations of soil drifting in relation to soil types, and also to secure samples for laboratory studies. The objectives sought were a comparison of the present conditions of soil drifting with those found during the earlier surveys, and some data on the chemical and physical composition of undrifted cultivated soils and related drifted material.

[1]Contribution from the Department of Soils.

The classification of Saskatchewan soils into zones, series, and types has been described in several papers by Joel (*4, 5, 6*) and is also discussed in the provincial soil survey reports (*2*). It will be sufficient here to list the zones in succession. Beginning with the semi-arid region of southwestern Saskatchewan, the main soil zones are: the semi-arid brown prairie; the semi-arid dark brown prairie; the sub-humid black park; and the sub-humid gray wooded. A sketch map showing the approximate location of the zones is given in Figure 1.

The soil series referred to in the following pages may be placed in four groups, each group consisting of soils having similar textural ranges and parent materials, but occurring in different zones. In each group the first named series occurs in the brown prairie zone, the second in the dark brown prairie zone, and the third in the black park zone. This series grouping is given below:

1. Sceptre, Regina and Indian Head Series. These are heavy textured soils derived from lacustrine deposits and Pierre shale.

2. Fox Valley, Elstow and Melfort Series. These include medium and heavy textured soils derived from silty lacustrine deposits.

3. Haverhill, Weyburn and Oxbow Series. These include medium and light textured soils derived from glacial till and morainic deposits.

4. Hatton, Asquith and Meota Series. These include light textured soils derived from pre-glacial sandstones and recent alluvial and aeolian deposits.

The relation of the above mentioned soil types to their tendency to drift is shown in Table 1. The soils are grouped according to the degree

TABLE 1.—THE OBSERVED RELATION OF SOIL DRIFTING TO SOIL TYPE IN SASKATCHEWAN

| Soil Zone | Soil Type | Observed Drifting |
|---|---|---|
| Brown Prairie | Sceptre —heavy clay; clay | Severe |
| Brown Prairie | Fox Valley —silty clay loam; silt loam. | Severe |
| Brown Prairie | Haverhill* —clay loam; loam; light loam. | Severe |
| Brown Prairie | Haverhill —sandy loams. | Severe |
| Brown Prairie | Hatton —sandy loams. | Severe |
| Brown Prairie | —sands | Severe |
| Dark Brown Prairie | Regina —heavy clay; clay. | Severe |
| Dark Brown Prairie | Weyburn —fine sandy loams. | Severe |
| Dark Brown Prairie | Asquith —sandy loams. | Severe |
| Dark Brown Prairie | —sands. | Severe |
| Dark Brown Prairie | Regina —clay loam. | Moderate |
| Dark Brown Prairie | Elstow —silty clay loam; silt loam. | Moderate |
| Dark Brown Prairie | Weyburn —clay loam; loam; light loam. | Moderate |
| Dark Brown Prairie | Asquith —light loam. | Moderate |
| Black Park | Indian Head—clay. | Severe |
| Black Park | Oxbow —sandy loams. | Severe |
| Black Park | —sands. | Severe |
| Black Park | Melfort —silty clay loam; silt loam. | Moderate |
| Black Park | Oxbow —clay loam; loam; light loam. | Moderate |
| Black Park | Meota —light loam; sandy loam. | Moderate |

*Severe drifting of Haverhill clay loam and loam is of local occurrence and affects only a small part of the total area of these soils.

of severity of drifting observed in the field. It is not to be inferred that the soils grouped under severe drifting are always found in this state. The degree of drifting in the Sceptre series, for example, varies from severe to none, according to local conditions. This table is intended to indicate the soil types on which some serious drifting is occurring at the present time.

The data in Table 1 indicate that in general the severe drifting occurs on the heavy and light soils. In the case of the brown soil zone, severe drifting also occurs on the silty soils of the Fox Valley Series, and in certain localities, on the medium textured glacial soils of the Haverhill series. Earlier observations, discussed in Soils Survey Report No. 9 (*2*), indicated that the soils of the above mentioned series were not subject to serious drifting. This year's observation showed that wherever these soils were drifting badly there had been a succession of more or less complete crop failures. It is reasonable to assume therefore that the increased severity of drifting is due in part to the disappearance of stubble and crop residues, coupled with the effects of cultural practices. In the dark brown zone, medium textured soils of the Elstow and Weyburn series, which are quite similar in general character to the Fox Valley and Haverhill soils, respectively, did not appear to be drifting so severely.

It is interesting to note that some drifting is occurring in the sub-humid park zone on soils that have a very high content of humus or decomposed organic matter. The opinion has been frequently expressed that one of the chief causes of drifting in southwestern Saskatchewan is the loss of humus as a result of prevailing agricultural practices. Such a soil as the Melfort silty clay loam, which is subject to drifting, contains far more humus than could be built up in the soils of the semi-arid brown soil zone.

Irrespective of zonal position a considerable amount of fresh drifting was observed in uncultivated fine sand and dune areas, probably the result of overgrazing or some other disturbance of the natural vegetation.

There are a number of soils not listed in the table which are very little subject to drifting. Among these may be mentioned the complexes of solonetz soils of the brown and dark-brown zones (including the so-called "burn-out" soils), and the medium textured podzolic and degraded soils of the park and wooded zones. Slight drifting has been noted on podzolic fine sandy loams and sands of the wooded zone.

It is not possible to state definitely the relationship of topography to soil drifting. Most of the soils under discussion have gentlv undulating to gently rolling topographies. The topography of many of the medium and light soils is rougher than that of the clay and silty lacustrine soils. In the strong'y rolling areas there appears to be a tendency for drifting to occur chiefly on knolls and ridges. This may be due to the relatively lighter texture of the soils in these positions and in part to their greater exposure to wind action compared to lower slopes. However, the strongly rolling and hilly lands under cultivation occupy but a smal part of the total cultivated area of the province.

While this paper is primarily concerned with wind erosion, it is worth while noting that in southern Saskatchewan water erosion has also been

observed. The latter type of soil erosion is occurring on lands having rough, hilly topography, and also on adjacent lands of more gentle slope and lower elevation. The areas affected are local in extent, but both gullying and sheet-erosion on a small scale are to be found on cultivated fields. It is possible that individual farms may suffer considerable damage from this form of soil erosion.

The serious effects of drifting are most clearly seen on the lighter soil types, particularly on the sandy loams and sands. The effects are shown by damage to crop growth and destructive changes in the original soil. Severe drifting exposes the sandy subsoil, while the drifted material accumulates in miniature sand dunes. As a result, many fields formerly under cultivation are now practically devoid of vegetation and have been abandoned.

In the case of the clay soils, the fertility of both the drift and the soil seems to be practically unimpaired, as is shown by the uniformly good growth of vegetation occurring on such lands when moisture conditions again become favorable. The drift appears to be quite as uniform in texture as the original soil.

The drifted material from medium textured glacial soils is of a distinctly sandy nature when compared with the original soil. However, in the case of medium silty types there is less textural difference between the drift and the soil. The increase in recent years of soil drifting on medium textured soils formerly regarded as fairly resistant to wind erosion is another factor which points to the seriousness of the problem at the present time.

## Laboratory Studies

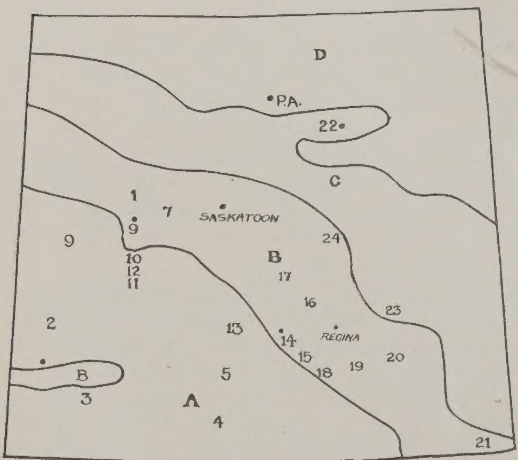


FIGURE 1.—Sketch map of southern Saskatchewan, showing main soil zones and approximate locations where soil and drift samples were taken. A, brown prairie zone; B, dark brown prairie zone; C, black park zone; D, gray wooded zone. The figures show locations of samples and also refer to the sample numbers as reported in Tables 2 and 3.

The samples taken for laboratory study were selected to represent the cultivated surface soil and the drifted material from the same soil type, taken in the same vicinity. The approximate locations of the samples are shown in Figure 1.

The following determinations were made: observations of texture, structure and colour; effervescence with dilute HCl; colorimetric pH; hygroscopic moisture at 105° C.; loss on ignition at 550-600° C.; nitrogen by the Kjeldahl method; phosphorus by the volumetric method; and

mechanical analysis by E. Troell's modification of the G. W. Robinson method (*8*), adapted to the U.S. Bureau of Soils' classification of soil separates.

The location and description of each sample is given in Table 2. The drift material, as would be expected, consists of finer structural aggregates than are found in the related soils. The majority of the samples, both of soil and drift, are calcareous, as shown by their reaction to dilute HCl.

TABLE 2.—LOCATION AND DESCRIPTION OF SAMPLES

| Sample | Location | Series | Texture | Structure | Effervescence (HCl) |
|---|---|---|---|---|---|
| 9–Soil | Richlea | Sceptre | Heavy clay | Large granular—cloddy | Moderate |
| 9–Drift | Richlea | Sceptre | Heavy clay | Fine granular—cloddy | Moderate |
| 10–Soil | Sanctuary | Sceptre | Heavy clay | Fine granular—nutty | Moderate |
| 10-Drift | Sanctuary | Sceptre | Heavy clay | Granular—cloddy | Moderate |
| 12–Soil | Kyle | Sceptre | Heavy clay loam-clay | Granular—cloddy | Moderate |
| 12-Drift | Kyle | Sceptre | Sandy clay | Granular—single grain | Moderate |
| 8–Soil | Ridpath | Regina | Heavy clay | Granular—cloddy | Moderate |
| 8–Drift | Ridpath | Regina | Heavy clay | Granular | Slight |
| 14–Soil | Pasqua | Regina | Heavy clay | Fine granular—Cloddy | Moderate |
| 14–Drift | Pasqua | Regina | Heavy Clay | Fine granular—nutty | Moderate |
| 16–Soil | Lumsden | Regina | Heavy clay | Fine granular—cloddy | Strong |
| 16–Drift | Lumsden | Regina | Heavy clay | Fine granular | Moderate |
| 18–Soil | Wheatstone | Regina | Clay | Med. granular—cloddy | Slight |
| 18–Drift | Wheatstone | Regina | Clay | Fine granular—nutty | Moderate |
| 22–Soil | Beatty | Melfort | Silty clay loam | Granular—small cloddy | None |
| 22-Drift | Beatty | Melfort | Silty clay loam | Granular | Moderate |
| 23–Soil | Indian Head | Indian Head | Clay | Granular—cloddy | Moderate |
| 23–Drift | Indian Head | Indian Head | Clay | Fine—med. granular | Moderate |
| 2–Soil | Fox Valley | Fox Valley | Silty clay loam | Granular—cloddy | Faint |
| 2–Drift | Fox Valley | Fox Valley | Clay loam (silty) | Fine granular | Slight |
| 3–Soil | Shaunavon | Haverhill | Heavy loam | Granular—cloddy | Faint |
| 3–Drift | Shaunavon | Haverhill | Light loam | Granular—single grain | Faint |
| 4–Soil | Lakenheath | Haverhill | Clay loam | Fine granular—cloddy | Faint |
| 4–Drift | Lakenheath | Haverhill | Light loam | Granular—single grain | Faint |
| 7–Soil | Harris | Elstow | Clay loam (silty) | Granular—cloddy | None |
| 7–Drift | Harris | Elstow | Clay loam (silty) | Granular | Faint |
| 15–Soil | Briercrest | Weyburn | Heavy loam | Granular—cloddy | None |
| 15–Drift | Briercrest | Weyburn | Light loam | Granular—single grain | None |
| 17–Soil | Holdfast | Weyburn | Loam | Granular—cloddy | Moderate |
| 17–Drift | Holdfast | Weyburn | Light loam | Granular—single grain | Faint |
| 19–soil | Parry | Weyburn | Clay loam | Granular—cloddy | None |
| 19–Drift | Parry | Weyburn | Sandy loam | Granular—single grain | None |
| 20–Soil | Talmage | Weyburn | Clay loam | Granular—platy | None |
| 20–Drift | Talmage | Weyburn | Loam | Fine granular | None |

TABLE 2.—LOCATION AND DESCRIPTION OF SAMPLES—*Concluded*

| Sample | Location | Series | Texture | Structure | Effervescence (HCl) |
|---|---|---|---|---|---|
| 1–Soil | Kingsland | Weyburn | Loam, silty | Granular—cloddy | None |
| 1–Drift | Kingsland | Weyburn | Loam, silty | Fine granular—single grain | None |
| 5–Soil | Lake Johnston | Hatton | Light fine sandy loam | Single grain—granular | Faint |
| 5–Drift | Lake Johnston | Hatton | Sand | Single grain | Faint |
| 13–Soil | Mortlach | Hatton | Light sandy loam | Cloddy—nutty | None |
| 13–Drift | Mortlach | Hatton | Sand | Single grain | None |
| 11–Soil | Kyle | Haverhill | Light loam | Granular-nutty | None |
| 11–Drift | Kyle | Haverhill | Heavy sandy loam | Granular—single grain | None |
| 21–Soil | Carnduff | Asquith | Fine sandy loam | Fine grain | Slight |
| 21–Drift | Carnduff | Asquith | Light sandy loam | Coarse grain | Moderate |
| 24–Soil | Lanigan | Asquith | Sandy loam | Single grain—soft clod | None |
| 24–Drift | Lanigan | Asquith | Sand | Single grain | None |

There is no indication that the drift tends to be more calcareous than the soil or vice versa; nor can it be stated that the drifting soils are necessarily calcareous, since approximately one-third of the samples showed no effervescence with acid. It may be noted that the clay soils and those of medium texture having a relatively high silt content, show little or no textural difference between the original soil and its related drift. On the other hand the drift from the medium glacial soils and the light soils is distinctly lighter in texture than the original soil.

The drift samples, when air dried, appeared in many cases to be slightly darker in colour than the corresponding soils. Except in a few cases, as noted later, the data for loss on ignition and nitrogen do not indicate that the darker colour is due to a higher content of organic matter in the drift. The pH of the samples varies from 6.8 to 8, with no distinct differences in reaction showing between soil and drift.

## Mechanical Analysis of Soil and Drift Samples

The textural relationship between soil and drift is shown definitely in Table 3, which contains the results of mechanical analyses determined on all samples. The figures for hygroscopic moisture, loss on ignition, total nitrogen and phosphorus are also given, and these will be discussed later. The samples are placed in the same order as in the preceding table, the heavy soils being placed first, followed by those of medium and light textures.

Referring to the data on mechanical analysis, it will be seen that as mentioned above, there is little difference between the textural composition of the clay soils and their related drift materials. The soils have a clay content of from 35 to 84%, (using round figures) a silt content of from 7 to 28%, and a sand content of from 2 to 43%. The drift samples, in comparison have 32 to 83% clay, 8 to 31% silt, and from 2 to 53% sand.

TABLE 3.—ANALYSES OF SOIL AND DRIFT SAMPLES

| Sample | Texture | Mechanical Analysis | | | Chemical Analysis | | | |
|---|---|---|---|---|---|---|---|---|
| | | % Clay | % Silt | % Sand | % $H_2O$ | % Ign. loss | % N | % P |
| 9–Soil | Heavy clay | 84.3 | 7.0 | 2.2 | 8.40 | 7.09 | 0.237 | 0.062 |
| 9–Drift | Heavy clay | 83.2 | 7.8 | 1.6 | 8.42 | 6.96 | 0.236 | 0.058 |
| 10–Soil | Heavy clay | 70.3 | 15.8 | 4.6 | 7.24 | 7.99 | 0.237 | 0.082 |
| 10–Drift | Heavy clay | 69.9 | 15.8 | 4.5 | 7.83 | 6.75 | 0.216 | 0.080 |
| 12–Soil | Clay | 34.9 | 14.3 | 42.8 | 3.92 | 5.8 | 0.206 | 0.038 |
| 12–Drift | Sandy clay | 32.2 | 10.5 | 53.2 | 3.29 | 4.53 | 0.158 | 0.030 |
| 8–Soil | Heavy clay | 58.9 | 24.9 | 7.3 | 5.85 | 6.49 | 0.274 | 0.071 |
| 8–Drift | Heavy clay | 55.6 | 31.2 | 6.8 | 5.25 | 7.04 | 0.266 | 0.067 |
| 14–Soil | Heavy clay | 74.1 | 16.1 | 2.5 | 7.18 | 7.66 | 0.254 | 0.068 |
| 14–Drift | Heavy clay | 72.5 | 15.7 | 2.8 | 6.89 | 7.69 | 0.251 | 0.068 |
| 16–Soil | Heavy clay | 66.8 | 24.7 | 4.2 | 6.15 | 5.45 | 0.161 | 0.064 |
| 16–Drift | Heavy clay | 61.3 | 26.9 | 4.5 | 6.16 | 7.20 | 0.260 | 0.076 |
| 18–Soil | Clay | 46.1 | 27.8 | 14.2 | 4.93 | 8.04 | 0.308 | 0.083 |
| 18–Drift | Clay | 49.3 | 22.4 | 19.1 | 4.73 | 7.15 | 0.280 | 0.073 |
| 22–Soil | Heavy silty clay loam | 51.0 | 28.4 | 8.1 | 5.17 | 14.45 | 0.637 | 0.115 |
| 22–Drift | Heavy silty clay loam | 56.6 | 29.1 | 7.8 | 5.21 | 12.97 | 0.538 | 0.114 |
| 24–Soil | Clay | 58.6 | 20.3 | 5.6 | 6.29 | 10.23 | 0.381 | 0.083 |
| 24–Drift | Clay | 63.9 | 20.0 | 6.3 | 6.57 | 10.13 | 0.374 | 0.116 |
| 2–Soil | Clay loam, silty | 23.9 | 44.1 | 32.2 | 2.63 | 5.00 | 0.174 | 0.051 |
| 2–Drift | Clay loam, silty | 23.4 | 37.0 | 39.8 | 3.22 | 7.28 | 0.382 | 0.058 |
| 3–Soil | Heavy loam | 22.5 | 36.8 | 36.7 | 2.78 | 5.72 | 0.259 | 0.083 |
| 3–Drift | Light loam | 19.45 | 18.9 | 60.0 | 1.78 | 3.67 | 0.149 | 0.040 |
| 4–Soil | Clay loam | 24.2 | 26.2 | 40.1 | 2.57 | 4.90 | 0.193 | 0.069 |
| 4–Drift | Light loam | 20.2 | 11.2 | 66.2 | 1.91 | 3.30 | 0.099 | 0.043 |
| 7–Soil | Clay loam, silty | 25.9 | 43.4 | 21.1 | 3.09 | 5.95 | 0.242 | 0.074 |
| 7–Drift | Clay loam, silty | 25.4 | 38.6 | 32.2 | 2.71 | 5.37 | 0.222 | 0.061 |
| 15–Soil | Loam | 22.5 | 33.2 | 36.8 | 2.7 | 5.64 | 0.241 | 0.048 |
| 15–Drift | Light loam | 26.4 | 10.9 | 58.9 | 2.27 | 3.97 | 0.160 | 0.043 |
| 17–Soil | Loam | 21.5 | 33.9 | 37.6 | 2.63 | 5.71 | 0.245 | 0.069 |
| 17–Drift | Light loam | 19.8 | 26.9 | 48.6 | 2.55 | 6.61 | 0.302 | 0.064 |
| 19–Soil | Clay loam | 27.3 | 29.8 | 38.4 | 2.69 | 6.74 | 0.203 | 0.075 |
| 19–Drift | Lt. loam—sandy loam | 1.9 | 27.5 | 69.1 | 1.53 | 2.51 | 0.099 | 0.039 |
| 20–Soil | Clay loam | 27.6 | 34.6 | 34.2 | 3.17 | 7.41 | 0.294 | 0.072 |
| 20–Drift | Loam | 26.1 | 23.4 | 47.8 | 2.73 | 6.14 | 0.251 | 0.068 |
| 1–Soil | Hvy loam, silty | 22.6 | 39.0 | 29.6 | 2.95 | 8.95 | 0.379 | 0.079 |
| 1–Drift | Hvy. loam, silty | 22.2 | 40.2 | 31.6 | 2.99 | 9.80 | 0.432 | 0.097 |
| 5–Soil | Light sandy loam | 8.1 | 8.9 | 80.8 | 1.13 | 2.49 | 0.153 | 0.045 |
| 5–Drift | Sand | 2.5 | 0.7 | 93.5 | 0.36 | 0.83 | 0.040 | 0.024 |
| 13–Soil | Light sandy loam | 15.8 | 2.5 | 79.4 | 1.75 | 2.02 | 0.066 | 0.023 |
| 13–Drift | Sand | 6.0 | 8.3 | 91.1 | 0.55 | 1.09 | 0.050 | 0.016 |
| 11–Soil | Light loam | 25.9 | 20.5 | 44.6 | 2.44 | 5.59 | 0.205 | 0.042 |
| 11–Drift | Hvy. sandy loam | 25.7 | 9.6 | 64.6 | 2.61 | 4.21 | 0.153 | 0.039 |

TABLE 3.—ANALYSES OF SOIL AND DRIFT SAMPLES—*Concluded*

| Sample | Texture | Mechanical Analysis | | | Chemical Analysis | | | |
|---|---|---|---|---|---|---|---|---|
| | | % Clay | % Silt | % Sand | % $H_2O$ | % Ign. loss | Nitrogen | P |
| 21–Soil | Sandy loam | 11.7 | 13.6 | 72.8 | 1.75 | 4.21 | 0.194 | 0.056 |
| 21–Drift | Light sandy loam | 10.7 | 8.6 | 78.3 | 1.16 | 3.09 | 0.151 | 0.061 |
| 24–Soil | Sandy loam | 6.9 | 13.4 | 75.6 | 1.15 | 4.58 | 0.238 | 0.040 |
| 24–Drift | Sand | 2.3 | 1.8 | 95.6 | 0.25 | 1.21 | 0.067 | 0.014 |

In the medium textured samples analyzed, the clay content ranges from 21.5 to 27.6% for the soils, and from 1.9 to 26% for the drift. The silt content in the soil varies from 26 to 44%, in the drift from 11 to 40%. The sand content in the soil varies from 21 to 40%, in the drift from 31 to 69%. The clay content is highest in the soil, except in the case of Sample 15 but the differences are not great except for Sample 19. The silt content is considerably higher in the soil than in the drift; the sand is always higher in the drift and generally the difference is considerable. Samples 1, 2 and 7, representing medium heavy silty types, show less difference between the soil and drift than is the case with the remaining samples, which are of glacial origin. It should be mentioned that in order to save time the sand was not separated into its various fractions. Observations of the total sand fractions of the above silty types and also of the heavy samples showed that they were predominantly very fine sand.

For the medium textured samples the potential value of the drift materials as indicated by the textural character is in all cases poorer than for the original soils, due to the increase in the sand fraction. In six of the samples the drift contains from 50 to 66% sand, thus putting the samples into the sandy loam class. The clay content is high enough in most cases to give a textural "feel" of a light loam.

The light soils, as would be expected, show a complete contrast in mechanical composition to the heavy soils. In the latter the clay is the dominant fraction, while in the light soils the sand is present in greatest amount.

In the case of the sandy loams, the soils contain from 72 to 81% sand; the drift samples from 78 to 96% sand. The silt and clay fractions, though present in much smaller percentages than in the heavier samples, exhibit great variation between soil and drift.

The clay content of these soils varies from 6.9 to 15.8%; of the drift from 2.3 to 10.7%. The silt content of the soil ranges from 2.5 to 13.6%; of the drift from below 1% to 8.6%. The clay and silt are always higher in the soil than in the related drift. Sample 11, which is bordering on the sandy loam class, has about the same clay content in soil and drift; the silt content of the soil is double that of the drift, however, and the drift contains 20% more sand than the soil. Sample 13 is interesting in that it is really a subsoil and represents the residual material after at least three and one-half feet of top soil have been blown away. This explains its relatively high clay content.

TABLE 4.—AVERAGE MECHANICAL COMPOSITION OF HEAVY, MEDIUM AND LIGHT SAMPLES OF SOIL AND DRIFT

| Samples | % Clay | % Silt | % Sand |
|---|---|---|---|
| Clay Soils (9 samples) | 60.5 | 19.86 | 10.20 |
| Drift from Clay Soils (9 samples) | 60.5 | 19.90 | 10.70 |
| Clay loam and loam soils (9 samples) | 24.22 | 35.66 | 34.10 |
| Drift from Clay Loam and loam Soils (9 samples) | 20.50 | 26.10 | 50.40 |
| Sandy Loam Soils (5 samples) | 13.60 | 11.70 | 70.00 |
| Drift from sandy Loams (5 samples) | 9.40 | 5.80 | 84.60 |

The differences in mechanical composition between the soil and drift in heavy, medium and light textured samples are summarized in Table 4. The average content of clay, silt and sand of all the heavy soils, together with that of the corresponding drift materials are shown first, followed by similar data for the medium and light textured soils and their related drift materials.

This table indicates that the average mechanical composition of the heavy soils and drifts is almost identical; furthermore, both soil and drift must be placed in the clay class. The medium textured soils theoretically average a clay loam, but the related drift can only be considered a light loam. The light textured soils as averaged have the composition of a sandy loam, while the average of the related drift materials is merely a sand. The above differences in mechanical composition of the samples are also shown graphically in Figure 2.

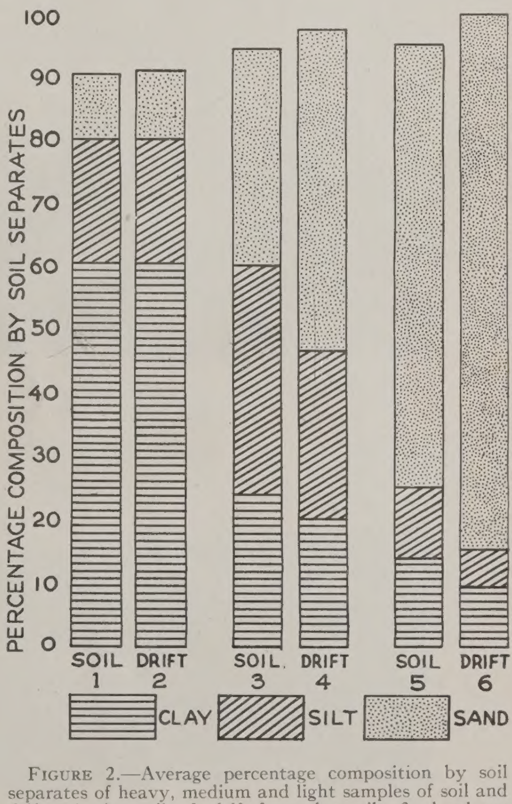


FIGURE 2.—Average percentage composition by soil separates of heavy, medium and light samples of soil and drift. 1, clay soils; 2, drift from clay soils; 3, clay loam and loam soils; 4, drift from clay loams and loams; 5, sandy loams; 6, drift from sandy loams.

These results suggest that the clay soils drift in the form of a granule or compound particle having essentially the same mechanical composition as the soil as a whole. In the medium and light textured soils there is apparently a definite sorting out of the sand fraction, whereby the drift is higher in sand and correspondingly lower in clay and silt than the soil. Some of the clay and silt blown out of the medium and light soils is apparently not deposited with the more sandy drift, but is presumably carried by the wind to a greater distance.

## Chemical Analysis of Soil and Drift Samples

Referring again to Table 3, the figures for hygroscopic moisture, loss on ignition, nitrogen and phosphorus, furnish additional data on the differences between soil samples and the corresponding drift materials. The figures for hygroscopic moisture give a rough idea of the relative amounts of colloidal material present. In general, higher figures for hygroscopic moisture correspond to higher percentages of clay and silt. The highest figure for moisture (8.4%) is found in Sample 9, a heavy soil

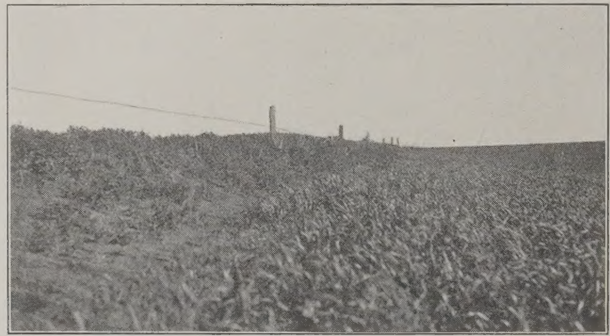

FIGURE 3.—A good stand of wheat on drifted Regina clay.

FIGURE 4.—The remains of a cultivated field of Hatton sandy loam, the surrounding soil having drifted down 3½ feet.

of the Sceptre series having a clay content of over 80%. The lowest figure for moisture is 0.25%, found in a drift sample of the Asquith sandy loam which contains over 95% sand. The medium and light textured samples, which exhibit the greatest differences in mechanical composition between soil and drift, also show greater differences in moisture content as compared with the heavy samples.

While it is recognized that the determination of loss on ignition as a measure of the organic matter content is open to serious error, in this study the determination agrees fairly well with the known facts regarding the organic matter content of Saskatchewan soils. The agreement between loss on ignition and nitrogen is generally satisfactory. In practically all cases, both in soil and drift samples, higher loss on ignition values correspond with higher percentages of nitrogen. In most of the samples the ignition and nitrogen values are higher in the soil than in the related drift. Notable exceptions to this occur in the data for Samples 1 and 2, in which the reverse is true. In both these cases the drift sample was found to

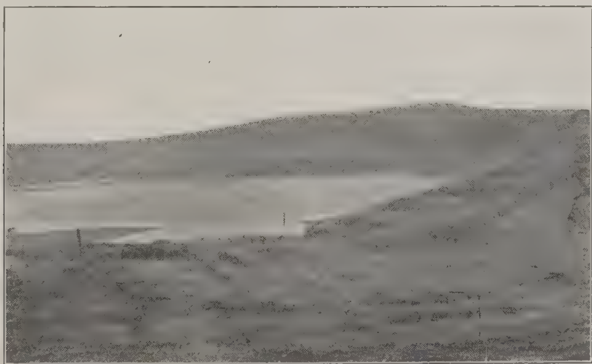

FIGURE 5.—A combination of wind and water erosion of Haverhill clay loam and loam.

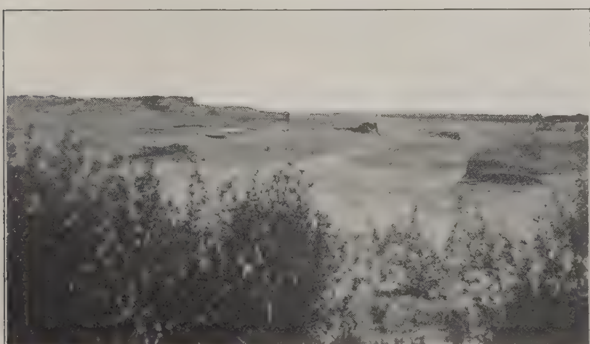

FIGURE 6.—Wind erosion in uncultivated sand dune area, adjacent to abandoned field carrying sweet clover and brome grass.

contain considerable undecomposed plant material, in such a fine state of division that it could not be properly separated from the mineral soil. Samples 16 and 17 also show higher ignition and nitrogen values in the drift, but the cause in this case was not apparent.

The nitrogen content is not excessively low except in the sandy drifts (Samples 5, 13 and 24) and in the exposed subsoil in Sample 13. Only two medium textured drifts (4 and 19) have a nitrogen content below 0.1%. Values for loss on ignition and nitrogen are highest in the heavy black park soil of the Melfort series, represented by Sample 22. In this soil the ignition loss is 14.45% and the figure for nitrogen is 0.637%. The drift in this same sample has an ignition loss of 12.97%, while the nitrogen value is 0.538%.

In distinct contrast to these figures, the lowest results occur in a sandy soil of the brown prairie zone, represented by the Hatton series (Sample 5); the soil has an ignition loss of 2.49% and a nitrogen content of 0.153%. The drift has an ignition loss of 0.83% while the figure for nitrogen is 0.04%. It is thus interesting to note that the highest loss on ignition figures coincide with the highest values for nitrogen, and conversely, the lowest loss on ignition is found in the samples having the lowest figures for nitrogen.

The Melfort series referred to above, together with the Indian Head series (Sample 23), represent the heavy textured fertile soils of the sub-humid black park zone. The figures for loss on ignition and nitrogen indicate a much higher content of organic matter than is found in the soils of the semi-arid brown prairie zone. This fact supports the view suggested in the discussion of the field observations above, namely, that a high content of organic matter, largely in the form of humus or decomposed organic matter, is no assurance that a soil will not drift. Harrison (*3*) found little relation between loss on ignition and tendency to drift in Manitoba soils, and suggested that drifting was caused by the absence of fibre.

The results of the phosphorus determinations show the same general trend as the values for the nitrogen, particularly where the latter is present in relatively high amounts. The highest values for phosphorus occur in the Melfort and Indian Head soils (samples 22 and 23) while the lowest values are found in the sandy drifts from the Hatton and Asquith fine sandy loams (Samples 13 and 24).

The phosphorus values do not follow the same order as those of nitrogen in all cases, however. The data in Table 3 indicate that there is a general tendency for lower phosphorus figures in those samples relatively high in sand.

The percentages of nitrogen and phosphorus present in the soil samples of the normally productive heavy and medium types indicate that these soils are potentially very fertile. The cause of the present drifting condition of these soils is not due therefore to their having become "worn-out" or "run-down" agriculturally, as some have asserted. In so far as laboratory analysis is an index of soil fertility, the figures for mechanical analysis, moisture and loss on ignition give additional support to the conclusions drawn from the values for nitrogen and phosphorus.

The data for hygroscopic moisture, ignition, nitrogen and phosphorus are summarized in Table 5, which gives the average figures for these determinations in heavy, medium and light soils and the corresponding drifts.

TABLE 5.—AVERAGE CHEMICAL COMPOSITION OF HEAVY, MEDIUM AND LIGHT SAMPLES OF SOILS AND DRIFT

| Samples | % $H_2O$ | % Ign. loss | % N | % P |
|---|---|---|---|---|
| Clay Soils (9 samples) | 6.12 | 8.13 | 0.324 | 0.073 |
| Drift from Clay Soils (9 samples) | 6.04 | 7.82 | 0.308 | 0.076 |
| Clay loam and loam soils (9 samples) | 2.80 | 6.22 | 0.238 | 0.069 |
| Drift from clay loam and loam soils (9 samples | 2.42 | 5.63 | 0.233* | 0.055 |
| Sandy loam soils (5 samples) | 1 64 | 3.78 | 0.171 | 0.041 |
| Drift from sandy loam soils (5 samples) | 0.98 | 2.08 | 0.092 | 0.031 |

*The relatively high percentage of nitrogen in the medium drift is due to the inclusion of the abnormal nitrogen values of the drifts from Samples 1 and 2. Excluding these samples the average percentage would be 0.183.

## CONCLUSIONS

The laboratory data presented above confirm the field observations made with respect to soil drifting in Saskatchewan. The drifted material from heavy soils is practically identical in mechanical composition with the undrifted soil. The same is true generally for the values for hygroscopic moisture, loss on ignition, nitrogen and phosphorus. On the other hand the drift from sandy soils has a much lighter texture and lower values for the above constituents than the undrifted soil. The drift from medium textured glacial types is also lighter than the original soil, but is potentially more fertile than the drift from sandy soils.

While much of the drifted material is piled along fences and roadsides, a considerable amount is also deposited in cultivated fields. It is obvious that if a normally productive field receives a deposit of drift from a sandy soil, the fertility of such land may be seriously impaired or even permanently destroyed. In addition to the above factor there is another reason why light soils constitute the most serious problem of soil drifting. In many areas the natural surface soil has been eroded by wind to such an extent that the sandy subsoil, low in organic matter and natural fertility is exposed as the present surface. Sample No. 13 is an example of this condition, and from the standpoint of soil fertility both soil and drift are of low agricultural value. Finally, it may be pointed out that sandy loam soils of semi-arid regions cannot be considered good agricultural soils, apart from their tendency to drift, on account of their relatively low moisture holding capacities.

It has been shown that the problem of drifting on the light soils is a serious one from many aspects. However, the need for measures of effective control of drifting on the heavier, more fertile soils is equally important, since such soils have a higher potential productivity than the lighter types and the losses incurred through drifting are consequently greater. The necessity of considering soil type in any investigations dealing with soil drifting is evident.

### SUMMARY

1. Observations made in Saskatchewan during the summer of 1934 indicate that soil drifting or wind erosion is generally most severe on the very heavy and the very light soils. Similar observations were made several years ago during the course of the soil survey work. There is, however, a definite tendency during the present period of drought for serious drifting to develop on medium-textured soils formerly classed as relatively non-drifting types.

2. The investigations indicate that serious drifting is occurring on a number of soil series, representing a variety of soil textures, parent materials and zones.

3. The occurrence of soil drifting in the black park zone indicates that the presence of a high content of humus or decomposed organic matter does not prevent a soil from drifting.

4. The analyses show that the clay soils and the corresponding drifted materials are practically identical in composition. Soil drift from sandy loam areas is poorer in textural grade and chemical composition than the original soil. Drift from medium textured soils exhibits a similar tendency, but the differences between soil and drift are not so great.

5. The analytical data suggest that the samples of heavy and medium textured soils are potentially quite fertile. There is no indication that the present tendency of these soils to drift is due to any serious loss in their productive capacities.

6. While the investigation indicates that the soil drifting problem is most serious on the lighter soil types, the heavier soils also demand attention since they are much more valuable agriculturally.



### ACKNOWLEDGMENTS

Special acknowledgment is due Mr. A. Tzogoeff who assisted materially with the analytical work. Acknowledgment is also due Dr. J. Mitchell, Professor of Soils at the University of Saskatchewan, for co-operation in the field studies and helpful criticism of the paper.


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## Résumé

**Quelque études dans le champ et au laboratoire des tourbillons de poussière en Saskatchewan. H. C. Moss, Université de la Saskatchewan, Saskatoon, Sask.**

Des observations faites en Saskatchewan pendant l'été de 1934 montrent que les tourbillons de poussière, c'est-à-dire l'érosion du sol par le vent, sont généralement plus graves sur les sols très lourds et très légers qu'ailleurs. Il a été fait des observations du même genre, il y a plusieurs années, au cours de l'étude des sols. Cependant pendant la période actuelle de sécheresse, on constate une tendance bien nette à la marche de l'érosion sur les sols de texture moyenne, autrefois classés parmi les types qui ne se soulèvent pas au vent. Les recherches indiquent qu'une grave érosion se produit sur un certain nombre de sols de texture variée, différents au point de vue des matériaux de formation et des zones. L'érosion par le vent dans la zone noire des parcs indique que la présence d'une haute proportion d'humus ou de matière organique décomposée n'empêche pas le sol de se soulever au vent. Les analyses montrent que les sols d'argile et les matériaux correspondants qui en proviennent sont d'une composition à peu près identique. Les matériaux enlevés par le vent des sols sablo-argileux sont plus pauvres en texture et en composition chimique que le sol original. Les matériaux provenant des sols à texture moyenne exhibent une même tendance mais les différences entre le sol et les matériaux enlevés ne sont pas aussi grandes. Les données des analyses portent à croire que les échantillons de sol à texture lourde et moyenne sont potentiellement très fertiles. Il n'y a aucune indication que la tendance actuelle à l'érosion soit due à une diminution sérieuse de leur capacité de production. Les recherches qui ont été faites indiquent que le problème de l'érosion est surtout grave sur les types de sol plus légers, mais les sols plus lourds exigent également de l'attention car ils ont plus de valeur au point de vue agricole.

# A COMPARISON OF DIFFERENT TYPES OF ROOT ROT OF WHEAT BY MEANS OF ROOT EXCAVATION STUDIES[1]

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## INTRODUCTION

Several papers concerning the normal development of Marquis wheat (*9*) and its responses to artificial amputation of different parts of the root systems (*7, 8*) have already been published by Simmonds and Sallans. The present paper deals with root excavation studies of Marquis wheat when attacked by different types of root rot in the field. This method of studying root-rot problems has yielded valuable information concerning the position and extent of the injury to the root systems of wheat from diseases of this kind.

## MATERIALS AND METHODS

Fields were selected in which natural infections of the various root rots had developed. Beginning with the seedling stage the main roots of a number of typically diseased plants were excavated by Weaver's method (*12*). Data relating to the development of the whole plant, and to the position and extent of typical lesions on the roots and stem bases were taken. At the same time plants of healthy appearance were selected close at hand and similar data concerning these were taken. The actual lengths and the courses followed by the main roots were ascertained definitely but it was almost impossible to excavate the branch rootlets fully by the method used. A large number of the excavated roots were examined microscopically for signs of the various pathogens primarily responsible for the diseased condition. Similar excavations and examinations were made in the same fields at midseason and just previous to the maturity of the wheat. In most cases small blocks of earth containing additional plants were dug out and the earth was washed from their roots. In this way supplementary data on relative numbers and infection of lateral rootlets were obtained. Measurements of the height of the plants were made from the seed level to the tip of the tallest leaf in the seedling and midseason stages, and to the tip of the tallest head at the mature stage. In several instances the investigation was complicated by the fact that more than one type of root rot were present on the plants selected for study but in such cases the type being studied was much more in evidence than the others. Moreover, it was nearly impossible to find perfectly healthy specimens, but the plants designated as healthy in this paper were only slightly affected by any of the root rots.

In referring to the roots and basal parts of the wheat plant the same nomenclature is used as that employed in previous articles of this series. All of the roots arising at the lower end of the subcrown internode are

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classed as seminal roots. At the same time it is thought that a small proportion of these roots are not true seminal roots because their primordia are never visible in sections of the resting embryo and they emerge just above the attachment of the coleoptile instead of just below it. Percival (*4*) calls these roots the "coleoptile pair" and McCall (*2*) refers to them as "coleoptile axillary roots" and states that there may be as many as three of these on one plant. During these studies it was found that there was, on the average, approximately one coleoptile axillary root per plant.

## TYPES OF ROOT ROT STUDIED

The root rots of cereals, prevalent in Saskatchewan, may be divided into several distinct types. The three types which are of greatest economic importance at the present time are "common root rot," "take-all" and "browning root rot."

Common root rot usually is caused by *Helminthosporium sativum* P.K. & B. and by *Fusarium* spp. in this region. This disease may arise either from seed-borne infection or from the causal organisms living in the soil. The symptoms consist of brownish lesions on the roots, subcrown internodes, crowns, bases of the culms, and sheaths of the lower leaves, together with more or less severe stunting (*1*). Under moist conditions, signs of the causal organisms, in the form of mycelia and conidia, may be found developing in and on the affected parts. Under Saskatchewan conditions this disease usually does not produce an appreciable amount of seedling blight. As a rule the plants live through to maturity but the yield of grain is reduced. More or less of this disease is present annually in practically every field of wheat throughout the province.

Take-all is a root rot caused primarily by *Ophiobolus graminis* Sacc. In typical cases it is easily distinguished from the other types found in this region by the distinct blackening of the affected parts and by the presence of the characteristic brown mycelium of the causal organism (*5*). Plants severely affected with take-all usually die before reaching maturity. In the field this disease is more severe in comparatively wet seasons. Under dry conditions the symptoms are less conspicuous and the blackening and decay are mainly confined to the seminal roots and the subcrown internode. This has been termed "dry-weather take-all" (*6*). Take-all is most prevalent in comparatively new fields in districts which are fairly well wooded.

Browning root rot is caused primarily by *Pythium* spp. (*10*). In the seedling stage of wheat this disease is characterized by yellowing and death of the lower leaves followed by discolorations in which brown shades predominate. At the same time the seedlings become unthrifty and stunted. The laterals of the seminal roots, when examined under the microscope, present a discoloured, sickly appearance and many of the crown roots are cut off by severe lesions within a few inches of the crown. The diseased laterals and the crown roots at the points where they are rotted off usually contain an abundance of *Pythium* oospores (*11*). The diseased plants rarely die but recover to some extent as the surviving crown roots become established. The plants regain their green colour but remain more or less stunted and spindly right through to maturity. Maturity is delayed and

yields are reduced. Browning root rot is widely distributed throughout the province of Saskatchewan. This disease is most noticeable in wheat grown on summer-fallow, but it is not confined to such fields.

The causal organisms of these three types of root rot belong to widely different groups of fungi. Various methods of control must be employed to deal effectively with the different types. The symptoms of the three types described in this paper differ in many respects. The excavation studies described below help to explain why some of these differences exist.

## EXCAVATION STUDIES

*Common root rot*

The excavations of plants affected by common root rot were made in 1933 and 1934 at Indian Head, Saskatchewan. As the development of the normal plant and of the disease are both affected by the environmental conditions, brief descriptions of the weather conditions prevailing during the two growing seasons in question are given.

TABLE 1.—DATA SHOWING THE TOTAL MONTHLY PRECIPITATION AND THE MEAN AIR TEMPERATURES FOR THE MONTHS OF APRIL, MAY, JUNE AND JULY, AT THE THREE POINTS WHERE EXCAVATION STUDIES WERE CONDUCTED. TEN-YEAR AVERAGES OF SIMILAR DATA ARE GIVEN FOR COMPARISON

| Place | Year | Precipitation | | | | | Mean monthly air temperatures | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | April | May | June | July | 4-mo. Total | April | May | June | July | 4-mo. average |
| | | inches | inches | inches | inches | inches | ° F. | ° F. | ° F. | ° F. | ° F. |
| Indian Head | 1933 | 1.54 | 4.23 | 3.22 | 0.86 | 9.85 | 34.9 | 53.2 | 64.1 | 65.7 | 54.5 |
| | 1934 | 0.28 | 0.67 | 2.89 | 1.15 | 4.99 | 39.9 | 57.1 | 58.6 | 66.3 | 55.5 |
| | 10-year ave. (1922-1931) | 0.82 | 1.67 | 3.02 | 1.96 | 7 47 | 37.3 | 49.8 | 59.1 | 63.2 | 52.4 |
| Muenster | 1933 | 0.80 | 2.28 | 1.80 | 2.12 | 7.00 | 34.2 | 51.2 | 61.2 | 62.3 | 52.2 |
| | 1934 | 0.40 | 0.30 | 4.93 | 1.00 | 6.63 | 36.5 | 53.4 | 55.1 | 63.4 | 52.1 |
| | 10-year ave. (1922–1931) | 0.76 | 1.66 | 2.67 | 2.33 | 7.42 | 36.3 | 49.0 | 57.4 | 62.9 | 51.4 |
| Saskatoon | 1933 | 0.39 | 1.90 | 1.00 | 0.98 | 4.27 | 37.8 | 53.5 | 64.3 | 66.8 | 55.6 |
| | 1934 | 0.79 | 0.39 | 4.01 | 1.09 | 6.28 | 41.4 | 58.6 | 57.5 | 65.8 | 55.7 |
| | 10-year ave. (1922–1931) | 0.65 | 1.55 | 2.53 | 1.92 | 6.65 | 38.0 | 50.9 | 59.5 | 65.1 | 53.4 |

The total monthly precipitation and mean monthly air temperature at Indian Head during the period from April to July, inclusive, are given in the first section of Table 1. Compared with the average data for the ten-year period of 1922 to 1931, inclusive, the precipitation for 1933 was high and that for 1934 was low. This difference in rainfall is reflected to some extent in the development of the healthy plants at maturity as shown in Table 2. Both seasons were comparatively warm.

Figures 1, 2 and 3 represent wheat plants affected with common root rot, together with typical specimens of healthy plants, produced under identical conditions. These illustrations are based on the data shown in Table 2. By the time the wheat had reached the late seedling stage

TABLE 2.—DATA SHOWING THE AVERAGE CONDITION OF PLANTS AFFECTED WITH COMMON ROOT ROT AND OF HEALTHY PLANTS GROWING NEARBY, AT THREE STAGES OF THEIR DEVELOPMENT

| Condition of plants | Stage | Year | Height of plants | No. of culms | | No. of leaves | Crown roots | | | Seminal roots | | | | | Yield of grain per plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | With heads | Without heads | | No. | Length | | No. | Length | | | | |
| | | | | | | | | Range | Total | | Primary | First pair | Second pair | Others | |
| | | | inches | | | | | inches | inches | | inches | inches | inches | inches | grams |
| Diseased | Seedling | 1933 | 9.2 | 1.0 | 0.90 | 8.5 | 3.5 | 0.5– 2.9 | 6.6 | 3.9 | 9.2 | 8.4 | 1.3 | 0.1 | — |
| Healthy | Seedling | 1933 | 10.5 | 1.0 | 1.50 | 11.2 | 4.7 | 0.5– 5.2 | 9.8 | 5.0 | 19.5 | 14.4 | 4.8 | 0.3 | — |
| Diseased | Seedling | 1934 | 11.0 | 1.0 | 1.20 | 10.6 | 4.6 | 0.5– 6.1 | 17.8 | 3.2 | 10.1 | 7.7 | 0.6 | — | — |
| Healthy | Seedling | 1934 | 12.7 | 1.0 | 1.80 | 11.6 | 4.4 | 0.5– 4.3 | 11.4 | 4.4 | 14.3 | 9.4 | 2.7 | 0.3 | — |
| Diseased | Midseason | 1934 | 17.2 | 1.0 | 1.80 | — | 5.7 | 1.0–11.9 | 30.7 | 4.2 | 14.3 | 16.6 | 5.0 | 1.2 | — |
| Healthy | Midseason | 1934 | 23.0 | 1.25 | 1.25 | — | 6.0 | 1.0–12.2 | 37.2 | 4.5 | 25.0 | 27.0 | 8.0 | | — |
| Diseased | Mature | 1933 | 32.0 | 1.5 | 0.70 | — | 8.5 | 1.0– 5.5 | 22.7 | 4.5 | 19.1 | 24.8 | 3.1 | 1.2 | 0.814 |
| Healthy | Mature | 1933 | 35.0 | 1.7 | 1.00 | — | 11.0 | 1.0– 8.7 | 42.4 | 4.3 | 30.3 | 21.5 | 1.8 | — | 0.973 |
| Diseased | Mature | 1934 | 23.0 | 1.0 | 1.30 | — | 7.7 | 1.0–14.0 | 34.6 | 4.0 | 22.5 | 20.1 | 0.9 | — | 0.396 |
| Healthy | Mature | 1934 | 29.0 | 1.5 | 1.75 | — | 9.7 | 1.0–16.0 | 45.7 | 5.0 | 27.1 | 32.2 | 3.8 | 2.2 | 0.742 |


FIGURE 1. Common root rot. Semi-diagrammatic drawings of representative seedlings of Marquis wheat excavated June 20th. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 2. The symptoms of common root rot at this stage are: brown lesions on the subcrown internode (broken line), slight lesions on the rootlets (dotted lines) and stunting of the whole plant.

(Figure 1), the diseased plants showed pronounced lesions on the subcrown internode, the root systems were somewhat impaired and the tops were stunted. The diseased plants possessed fewer tillers and leaves than the healthy plants. By midseason (Figure 2) the difference in the extent and condition of the root systems of diseased and healthy plants was still more noticeable. The diseased plants showed more lesions on the basal parts, they had fewer culms bearing heads and their development was retarded. The plants were nearly mature by the eighth of August (Figure 3). At this time there was not much difference in the comparative development of the root systems of diseased and healthy plants as compared with the plants at midseason, but lesions on the basal parts were somewhat more pronounced. The yield of grain from the diseased plants amounted to about 70% of the yield from the healthy plants.

*Take-all*

The excavations connected with this study of take-all were made in the Muenster district. The data, shown in the second section of Table 1, throw some light on the weather conditions prevailing in that district during the crop seasons of 1933 and 1934. Both seasons were comparatively warm. The total precipitation for the four-month period was a little below average in both years. The distribution of the rainfall over the period in question, however, was much more uniform in 1933. Both seasons were too dry to favour the development of pronounced blackening of parts affected by the disease, therefore the plants selected for this study were mostly of the "dry-weather take-all" type.

TABLE 3.—DATA SHOWING THE AVERAGE CONDITION OF PLANTS AFFECTED WITH TAKE-ALL AND OF HEALTHY PLANTS GROWING NEARBY, AT THREE STAGES OF THEIR DEVELOPMENT

| Condition of plants | Stage | Year | Height of plants | No. of culms | | Condition of leaves | | | Crown roots | | Seminal roots | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | With heads | Without heads | Green | Partly green | Dead | No. | Length | No. | Length: Primary | Length: First pair | Length: Second pair | Length: Others |
| — | — | | inches | | | — | — | — | — | inches | — | inches | inches | inches | inches |
| Diseased | Seedling | 1933 | 8.0 | 1.0 | 0.0 | 2 | 1 | 2 | 4 | 1– 3.5 | 6 | 15 | 10.5 | 4.0 | 1.0 |
| Healthy | Seedling | 1933 | 11.0 | 1.0 | 1.0 | .5 | 2 | 1 | 4 | 1– 3.0 | 6 | 18 | 12.5 | 4.5 | 1.0 |
| Diseased | Midseason | 1933 | 11.0 | 1.0 | 1.0 | 4 | 2 | 4 | 8 | 1.10.5 | 6 | 6 | 3.0 | 1.0 | 1.5 |
| Healthy | Midseason | 1933 | 19.5 | 1.0 | 2.0 | 11 | 5 | 7 | 15 | 1– 8.5 | 6 | 26 | 16.0 | 6.5 | 2.0 |
| Diseased | Midseason | 1934 | 13.0 | 1.0 | 1.0 | 1 | 2 | 5 | 8 | 1– 5.0 | 6 | 4 | 2.5 | 1.5 | 2.0 |
| Healthy | Midseason | 1934 | 27.5 | 1.6 | 1.0 | 4 | 3 | 6 | 11 | 1– 5.5 | 6 | 25 | 26.0 | — | 3.0 |
| | | | | | | Yield of grain | | | | | | | | | |
| Diseased | Mature | 1933 | 18 0 | 1.0 | 1.25 | 10 kernels per plant | | | 13 | 1– 7.0 | 6 | 2.5 | 2.5 | 1 5 | 1.0 |
| Healthy | Mature | 1933 | 35.0 | 2.5 | 1.5 | 60 kernels per plant | | | 25 | 1–16.0 | 6 | 34 | 33.0 | 12.0 | 10.0 |
| Diseased | Mature | 1934 | 18.5 | 1.0 | 0.6 | 0.25 grams per plant | | | 10 | 1– 6.5 | 6 | 7 | 4.0 | 2.0 | 2.5 |
| Healthy | Mature | 1934 | 34 0 | 1 8 | 1.2 | 1.05 grams per plant | | | 14 | 1–12.5 | 6 | 35 | 34.0 | 17.0 | 11.0 |

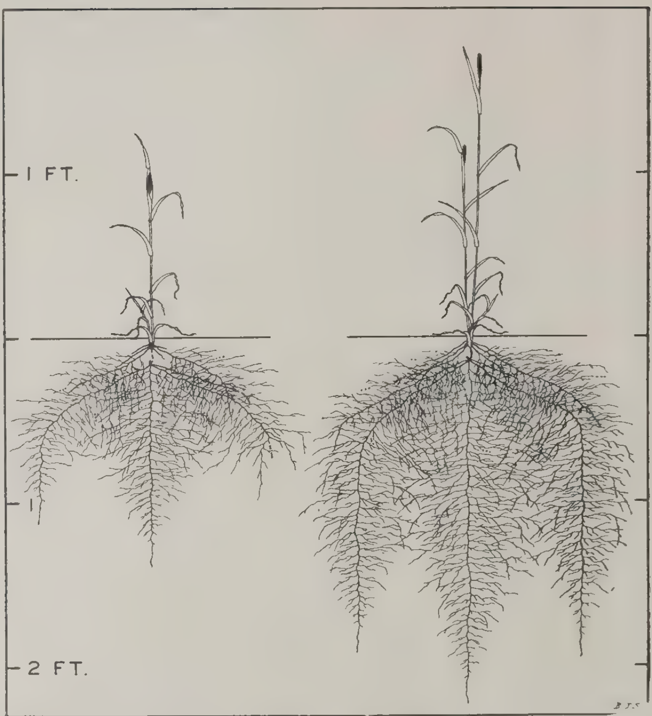


FIGURE 2. Common root rot. Semi-diagrammatic drawings of representative plants of Marquis wheat excavated July 12. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 2. The symptoms of common root rot at midseason were: severe lesions on the subcrown internode and certain roots (broken lines), slight lesions on the rootlets (dotted lines) and moderate lesions at the base of the lower leaf sheaths (stippling). In addition the affected plant is stunted and retarded in its development.

Figures 4–6 illustrate the appearance, at three different stages, of wheat plants affected with take-all and of healthy plants growing within a few feet of them. The drawings are based on data summarized in Table 3. Seedling stage excavations were made about the seventeenth of June (Figure 4). The seminal roots were already severely infected close to the seed, the subcrown internodes were partially blackened, the tops of the plants were noticeably stunted and the lower leaves were prematurely dead. The crown roots of the diseased plants were considerably further advanced in proportion to the relative size of the plants than were the crown roots of the healthy ones. This tendency toward premature development of the crown roots when the seminal roots are parasitized has been noted previously (*6*). By midseason (Figure 5) the seminal roots were almost completely destroyed and only the stubs could be excavated. The subcrown internode was blackened up to the crown and many of the crown

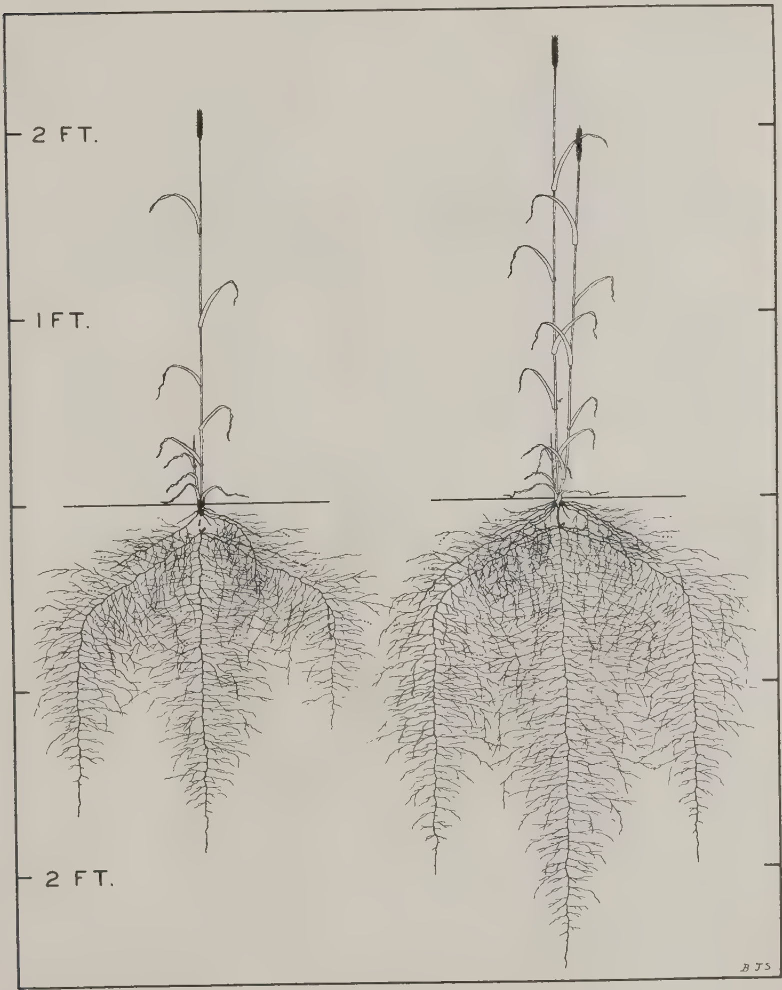


FIGURE 3. Common root rot. Semi-diagrammatic drawings of representative plants of Marquis wheat excavated August 8th. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 2. The symptoms of common root rot just before the plants are mature are similar but more pronounced than those exhibited by the host of midseason. The diseased plants yield much less grain than the healthy plants do.

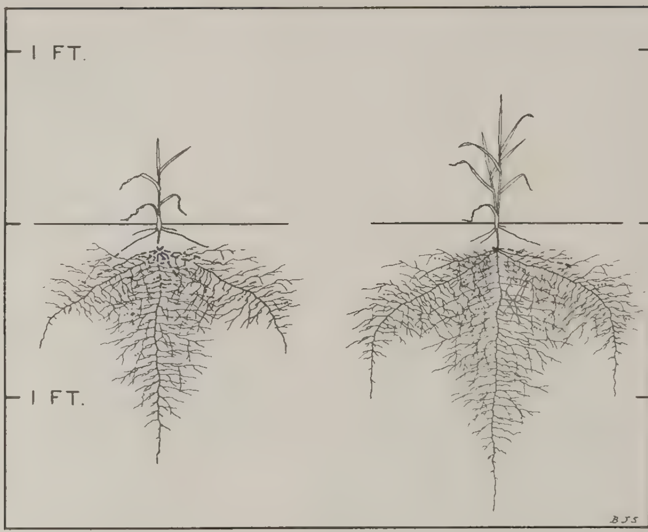


FIGURE 4. Take-all. Semi-diagrammatic drawings of representative seedlings of Marquis wheat excavated June 17th. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 3. The symptoms of take-all at this stage consist of: dark brown or black lesions on the subcrown internode and seminal roots, premature death of the lower leaves, and stunting of the whole seedling.

roots had become infected. By this time the development of the crown roots of the healthy plants far surpassed that of the crown roots of the diseased plants. The tops of the diseased plants were much more stunted in comparison with those of the healthy plants than was the case in the seedling stage, and only the topmost leaves were functioning. The final excavations were made about the ninth of August, just before the healthy plants had reached maturity (Figure 6). The diseased plants had made some further progress, due to additional development of crown roots, but their tops consisted of one stunted culm and one dead tiller per plant, with a poorly developed head containing somewhat shrunken grain. The yield of grain from the diseased plants amounted to about one-fifth of that from the healthy plants.

*Browning root rot*

A study was made of wheat affected with browning root rot in a field near Saskatoon in 1933. Conditions were exceptionally dry, the rainfall for the months of June and July being particularly scanty. Much of this rain came in the form of light showers and a large proportion of it evaporated and did not reach the roots. As a result, the plants were unable to establish any crown roots and at maturity they were only about fourteen inches high. The yield was practically nil. Moreover, suitable healthy

TABLE 4.—DATA SHOWING THE AVERAGE CONDITION OF PLANTS AFFECTED WITH BROWNING ROOT ROT AND OF HEALTHY PLANTS GROWING NEARBY, AT THREE STAGES OF THEIR DEVELOPMENT

| Condition of plants | Stage | Year | Height of plants | No. of culms | | Condition of leaves | | | Crown roots | | Seminal roots | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Length | | | |
| | | | | With heads | Without heads | Green | Partly green | Dead | No. | Length | No. | Primary | First pair | Second pair | Others |
| | | | inches | | | | | | | inches | | inches | inches | inches | inches |
| Diseased | Seedling | 1933 | 8.5 | 1 | 0 | 2 | 1 | 2 | 1 | 3.0 | 5.5 | 13.0 | 5 | 1.5 | 0.5 |
| Healthy | Seedling | 1933 | 13.5 | 1 | 2 | 9 | 2 | 1 | 5 | 0.5–5.5 | 4.6 | 13.0 | 9 | 1.5 | — |
| Diseased | Seedling | 1934 | 10.5 | 1 | 0 | 3 | 2 | 2 | 5 | 1.0–3.5 | 4.5 | 21.5 | 18 | 5.0 | 2.0 |
| Healthy | Seedling | 1934 | 18.5 | 1 | 2 | 11 | 3 | 1 | 11 | 0.5–9.0 | 4.0 | 24.0 | 23 | — | — |
| Diseased | Midseason | 1934 | 19.5 | 1 | 1 | 4 | 2 | 5 | 8 | 0.5–9.0 | 5.3 | 31.0 | 23 | 6.0 | 2.0 |
| Healthy | Midseason | 1934 | 32.0 | 2 | 2 | 3 | 6 | 8 | 19 | 0.5–22.0 | 5.0 | 35.0 | 32 | 9.5 | 6.5 |
| Diseased* | Mature | 1933 | 14.2 | 1 | 0 | 0 | 2 | 5 | 3 | 0.5–3.0 | 5.3 | 26.0 | 27 | 5.0 | 5.0 |
| Healthy | Mature | 1933 | — | — | | | | | | — | — | | | | — |
| | | | | | | Yield of grain | | | | | | | | | |
| Diseased | Mature | 1934 | 25.0 | 1 | 1 | 0.352 grams per plant | | | 7 | 0.5–9.0 | 5.0 | 33.0 | 24 | 3.5 | 1.0 |
| Healthy | Mature | 1934 | 37.0 | 3 | 1 | 1.782 grams per plant | | | 20 | 1.0–27.5 | 5.8 | 39.0 | 38 | 12.0 | 7.0 |

* These developed under severe drought. Average length of heads was only 1.4 inches.

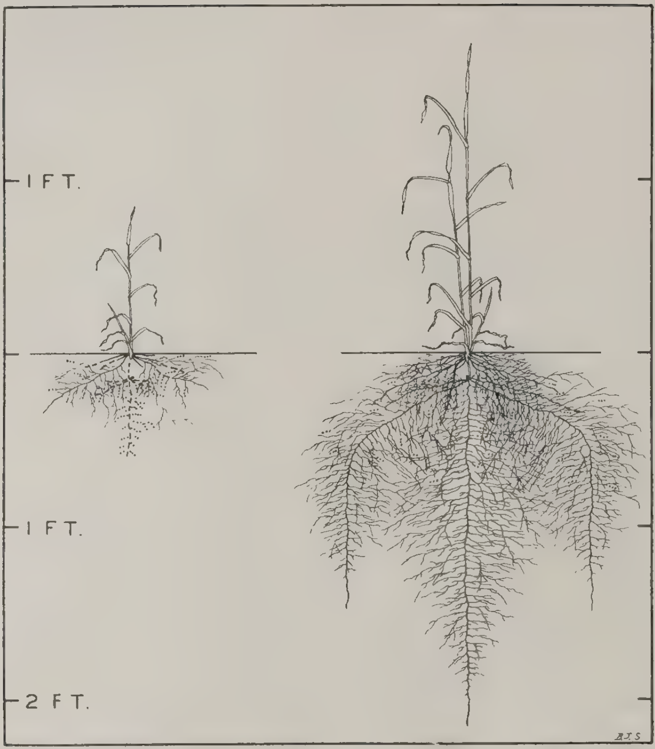


FIGURE 5. Take-all. Semi-diagrammatic drawings of representative plants of Marquis wheat excavated July 9th. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 3. The symptoms of the disease at midseason are: blackening and decay of the seminal roots and subcrown internode, slight lesions on the crown roots, premature death of the leaves, and marked stunting of the whole plant.

plants could not be obtained in this field. Therefore, although certain data concerning these plants are included in Table 4, they were not used in making the drawings shown in Figures 7–9. The illustrations are based on excavation studies conducted at Lanigan the following year. As Lanigan is near Muenster, the description of the weather conditions in 1934 in the foregoing section on take-all will suffice for both places.

The general effect of browning root rot on the wheat plant is illustrated in Figures 7–9. In the seedling stage (Figure 7) the attack of *Pythium* spp. centered first on the laterals of the early seminal roots and the tips and laterals of the later seminal roots. As the crown roots developed, gross lesions cut off many of them near the crown of the plant. The tops of the seedlings were stunted, and premature yellowing and death followed by

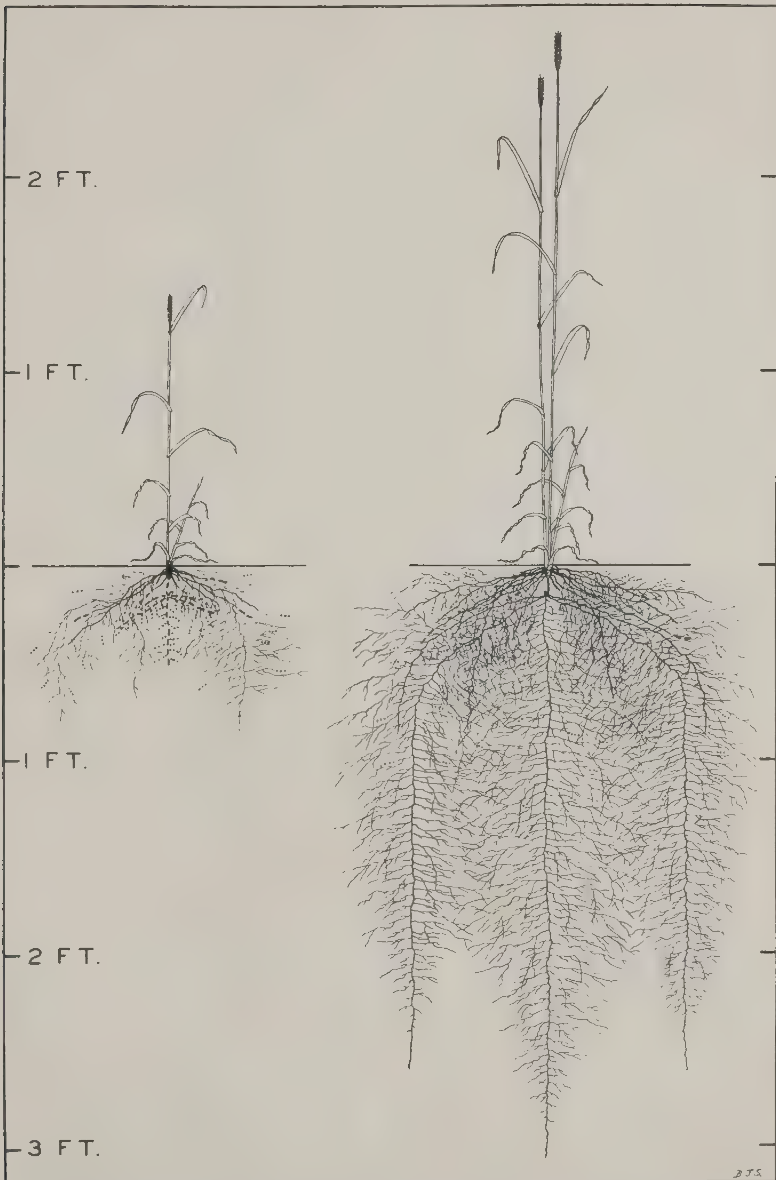


FIGURE 6. Take-all. Semi-diagrammatic drawings of representative plants of Marquis wheat excavated August 9th. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 3. The symptoms of take-all at this stage consist of: blackened vestiges of the destroyed seminal roots and subcrown internode, black lesions on the crown roots, pronounced blackening of the crown and basal leaf sheaths, and premature death of the whole top. The heads may be empty or they may be poorly filled with shrunken kernels.


FIGURE 7. Browning root rot. Semi-diagrammatic drawings of representative seedlings of Marquis wheat excavated June 20th. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 4. The symptoms of browning root rot at this stage are: partially disintegrated rootlets (dotted lines), gross brown lesions at the root tips (broken lines), premature death and brownish discoloration of the leaves, and marked stunting of the whole seedling.

brownish colouring and withering of the lower leaves was a conspicuous symptom at this time of year. By midseason (Figure 8) the diseased plants had established some crown roots, in spite of the destruction of a large proportion of them, and some of the seminal roots had continued to penetrate deeper into the soil developing fresh lateral rootlets as they grew. As a result, the diseased plants had resumed growth and regained a green appearance by developing new leaves, but they were still considerably stunted. They did not possess as many tillers as the healthy plants and the development of their heads was retarded. The healthy plants reached maturity sooner than the diseased plants. The final excavations were made on the seventh of August (Figure 9). All parts of the diseased plants were decidedly stunted. Their root systems had developed very little after midseason while those of the healthy plants had developed considerably during the same period. The yield from the diseased plants was reduced to about one-fifth of that from the healthy plants.

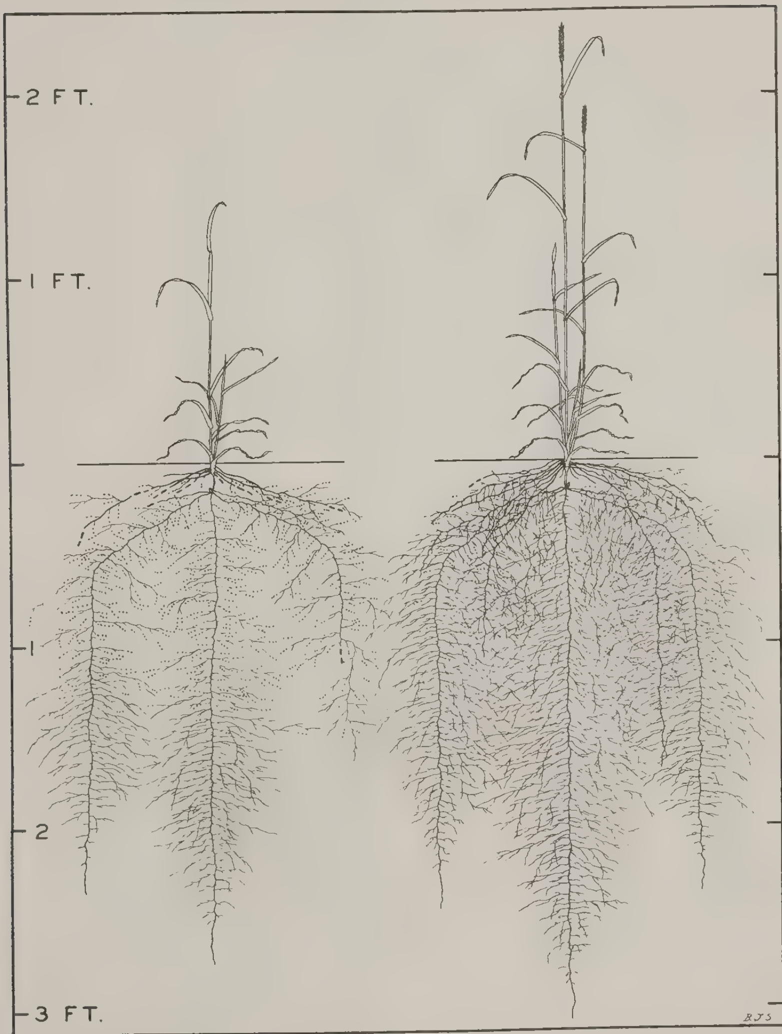


FIGURE 8. Browning root rot. Semi-diagrammatic drawings of representative plants of Marquis wheat excavated July 10th. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 4. The symptoms of this disease at midseason are very similar to the symptoms exhibited in the seedling stage (Figure 7) but the plant has regained a green appearance through the production of new leaves, and gross lesions at the tips of the crown roots are more noticeable.

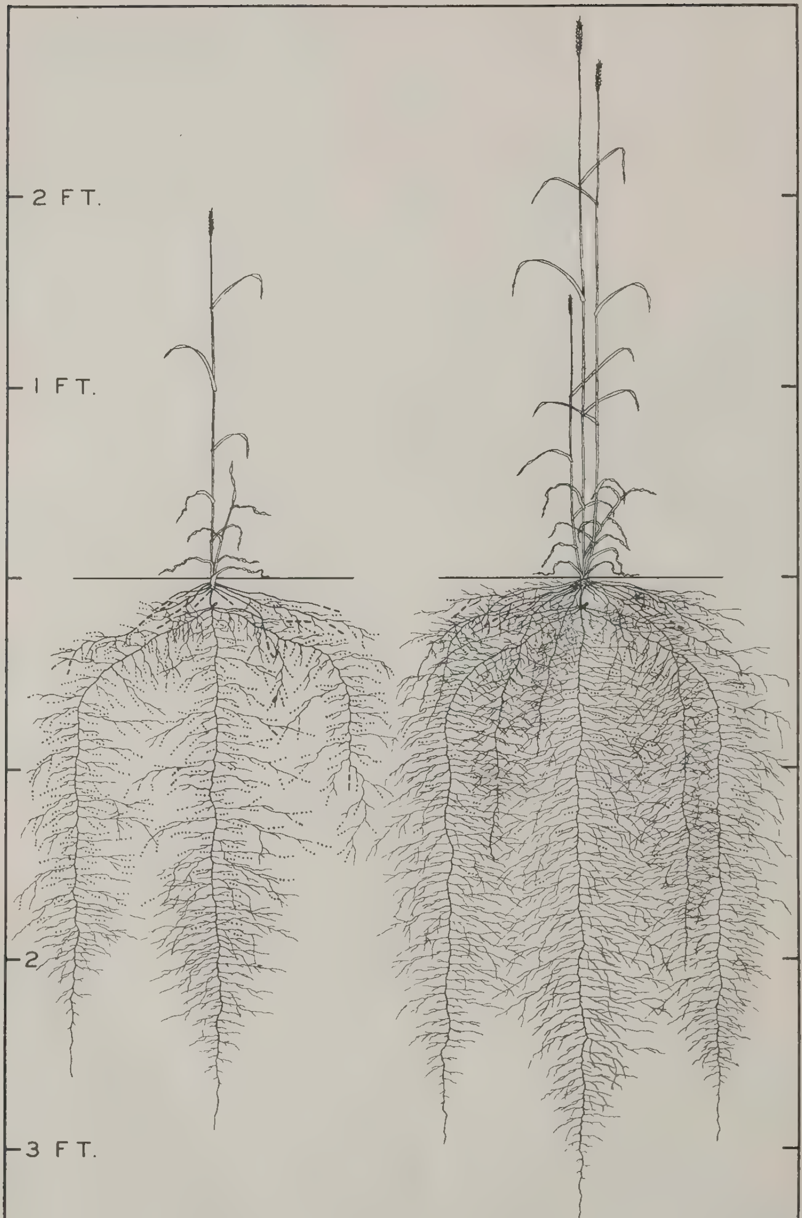


FIGURE 9. Browning root rot. Semi-diagrammatic drawings of representative plants of Marquis wheat excavated August 7th. The affected plant is represented on the left, and the healthy one on the right. These illustrations are based on data contained in Table 4. At this stage the chief symptoms of the disease are: gross lesions cutting off the crown roots, marked stunting of the whole plant, retardation of maturity, and reduction in yield.

## DISCUSSION

These excavation studies show that there are characteristic differences in the time and method of attack of the three types of root rot under investigation. Common root rot, if seed-borne, is apt to blight the seedlings either before or shortly after they emerge, but if the infection arises from the soil the disease is apt to be more gradual in its development. Even in its milder forms this disease destroys some roots, both seminal and crown, and interferes with the proper functioning of others which are less severely lesioned. Also it seems probable that the deeper lesions on the subcrown internode interfere with the upward passage of water and dissolved minerals from the seminal roots and with the downward translocation of food products manufactured by the plant. Frequently root initials and tiller buds are invaded and destroyed at an early stage. The action of this disease on the underground parts is clearly reflected in the top portion of the plant in the form of a stunted growth and a reduced yield of grain. Root rot is only one of the diseases produced in wheat by *H. sativum* and *Fusarium* spp., as these fungi sometimes attack the leaves and heads. The economic importance of common root rot is due largely to its ubiquity as it is present in all fields every year and may be found in any of the cereals commonly grown in this region.

The seminal roots of the host are attacked in the seedling stage by *O. graminis* and commonly they are completely destroyed. As in previous papers of this series, the seminal root system is shown to be of paramount importance to wheat grown under average field conditions in this region. Therefore, it can readily be seen that the loss of these roots seriously cripples the affected plants. Later, the disease may destroy the subcrown internode and attack the crown, crown roots and stem base just above the crown, particularly if conditions are relatively wet at midseason. The causal fungus appears to work at a depth of from one to ten inches below the surface of the soil under average conditions. If the plant is unable at any time to secure, through its impaired root systems, enough moisture from the soil to replace the water which it loses through transpiration, permanent wilting ensues and the plant dies. Other diseased plants may struggle through to maturity but the inability to get sufficient water keeps them in a more or less stunted condition, depending on environmental conditions and the extent of the injury to their root systems. As far as yields are concerned we find all gradations from plants which never come to a head to slightly affected plants which produce nearly a full normal yield.

The symptoms of browning root rot usually appear first in the early part of June. Unlike the causal organisms of common root rot and take-all, *Pythium* spp. do not produce lesions on the basal parts of the stem but confine their attack to the roots of the wheat plant. Before the crown roots emerge the causal fungi attack and destroy a large proportion of the lateral rootlets of the seminal root system. As a result, in severe cases the affected seedlings become unthrifty, most of their leaves die, starting with the lowest, and growth practically ceases for a time. However, the growing points of the older seminal roots are seldom destroyed and these continue to penetrate deeper into the soil and to form fresh lateral rootlets.

At the same time crown roots are developed and, although a large proportion of these may be cut off near the crown by severe lesions, the survivors become established and give support to the stunted seedling. Microscopic examinations of affected root systems showed that the parasite was most abundant in the top ten inches of soil although oospores were occasionally found in roots down to the 24-inch level. Wheat plants affected with browning root rot alone rarely die before maturity, under field conditions in this province, but they recover more or less rapidly and more or less completely, depending upon environmental conditions and the severity of the attack. Usually, the affected plants do not produce a normal number of tillers, they remain noticeably stunted, and their maturity is delayed. The reduction in yield of a severely diseased plant as compared with a healthy one may amount to as much as 80% but the reduction in yield from a whole field is seldom over 30%. The delay in maturity may result in a decided lowering of the quality of the yield due to rust epidemics or frosts.

To avoid confusion, we have treated the different types of root rot as though they were quite separate. As a matter of fact we frequently find that plants developing under ordinary field conditions are attacked by two or more types of root rot at one time. A striking example of such a case was found during these studies. At midseason a plant was excavated whose seminal roots had been completely destroyed by take-all, three out of four of its crown roots had been cut off by browning root rot, and lesions caused by common root rot appeared on the bases of the leaf sheaths. The plant was still living, supported by one crown root, about a foot in length, and its laterals. On the other hand one type often predominates over the other types in any one field.

The parts adjacent to the seed and the crown of the wheat plant are very vital parts from the standpoint of disease. Obviously, if the subcrown internode is destroyed at any point by a severe lesion the whole seminal root system is lost to the plant and it becomes entirely dependent on the crown roots. Take-all commonly destroys the seminal roots close to the seed and thus produces the same result. Infection about the crown may destroy tiller buds and crown root primordia while they are still in a very tender, susceptible condition and thus prevent their further development. Common root rot attacks the plant in this manner under favourable conditions. If the whole crown is destroyed the plant is certain to die. As far as we know, browning root rot does not attack the basal parts of the stem but mainly confines its attack to the laterals of the seminal roots in the upper ten inches of the soil and to the crown roots in the same soil stratum. Hence plants are rarely killed by this disease in the field.

The evidence indicates that all three types of root rot are most prevalent and destructive in the upper 10-inch layer of soil. This may be because the causal organisms find the environmental conditions much more suitable for their development in the loose top soil of high organic content than in the compact subsoil of low organic content.

Root rots undoubtedly have a marked effect upon root competition between cereals and weeds. Pavlychenko and Harrington (*3*) have shown the importance or root competition in the development of cereal crops in the presence of weeds. It has frequently been observed that weed

growth is much more vigorous in take-all patches and in fields which are severely stunted by browning root rot during the late seedling stage. Figures 1 to 9 enable one to visualize the great difference between the competition offered by a healthy wheat plant to the growth of weed roots and that offered by a wheat plant severely affected with root rot.

There appears to be a definite correlation between the proportion of the root systems which has been destroyed and the intensity of the symptoms produced by any root rot disease. Moreover, the physiologic processes of the plant may be affected by toxic substances produced when the causal organisms invade and kill the host tissues. Since light infections of any of the root rots produce only slight symptoms of disease, it is probable that root-rot damage in a mild form may frequently escape notice or be ascribed to other causes.

It has been pointed out in a previous paper (7) that the reactions of plants severely affected with root rot are comparable to the reactions of plants which have had certain of their roots amputated artificially. This is clearly the case when we compare the effects on the plant of a severe attack of take-all or browning root rot on the seminal roots, with the effects of seminal-root amputations. In each case the lower leaves of the host die prematurely, the plant becomes stunted and develops fewer tillers. If the seminal roots are amputated and a strong crown root system is developed the maturity of the plant is delayed. However, *O. graminis* commonly destroys most of the crown roots as well as the seminal roots so that maturity is hastened or the plant is killed before maturity. In cases of browning root rot, part of the seminal root system usually continues to function throughout the season and part of the crown root system is destroyed, so that although maturity may be delayed considerably the situation is not exactly comparable to the artificial amputation of the seminal roots followed by the undisturbed development of the crown root system. The similarity between the effects on the plants produced by the destruction of the crown roots by fungi and by artificial means is not so easy to discern because most cases of destruction of the crown roots by root-rot fungi are preceded by a severe infection of the seminal roots by the causal organisms.

## SUMMARY

1. Three types of root rot of wheat were investigated by excavating and studying the location and extent of the injury to the root systems of affected plants in the field. Healthy plants growing under the same conditions were studied similarly for comparison. The nature of the attack from the different types of root rot varied markedly in certain respects. Accordingly, the wheat plants reacted differently, giving the several symptom complexes which are characteristic of these three types of root rot.

2. Common root rot (*Helminthosporium sativum* and *Fusarium* spp.) was characterized by brown lesions on the subcrown internodes and certain of the roots by the time the wheat had reached the late seedling stage. Both tops and roots of the diseased plants were somewhat stunted. By

midseason, lesions were more pronounced on the subcrown internodes and roots, and were present on the crowns and basal leaf sheaths as well. The roots and tops appeared quite stunted and the development of the heads was retarded. By the time the healthy plants were nearly mature severe lesions were abundant on the basal parts, particularly the subcrown internodes of the diseased plants. Both roots and tops were considerably stunted and the yield from the diseased plants amounted to only 70% of the yield from the healthy plants.

3. Take-all (*Ophiobolus graminis*) was characterized by dark brown or black lesions on the seminal roots and subcrown internodes while the wheat was still in the seedling stage. The roots and tops of the affected seedlings were stunted. By midseason, the seminal root system was almost completely destroyed, more of the subcrown internodes were blackened and lesions were noticeable on certain of the crown roots and their branches. The tops were greatly stunted and only the youngest leaves remained green. By the time the healthy plants were nearly mature the seminal roots and subcrown internodes were entirely dead. The crown roots had developed to some extent after the midseason stage but some of them and many of their branches were destroyed. The tops were almost completely bleached and consisted of one stunted culm and one dead tiller. The heads were stunted and either empty or partially filled with more or less shrunken grain. The yield from the diseased plants amounted to only 20% of the yield from the healthy plants.

4. Browning root-rot fungi (*Pythium* spp.) first attacked and destroyed many of the lateral rootlets of the seminal root system. They also invaded the growing tips of some of the later seminal roots and a large proportion of the crown roots and cut them off in the late seedling stage. As a result, the majority of the leaves died, the seedlings became markedly stunted and growth almost ceased for a period. By midseason the diseased plants had recovered to some extent, due to the continued growth of the seminal roots and of the few crown roots which escaped destruction. By the time the healthy plants were nearly mature neither the seminal roots nor the crown roots of the diseased plants had shown much further development. The tops were not only greatly stunted but the heads were greener and less mature than those of the healthy plants. The yield from the diseased plants amounted to only 20% of that from the healthy plants.

5. The damage caused by root rots to the host appears to be approximately proportional to the portion of the root systems destroyed. The reductions in yield resulting from light infections of root rot often pass unnoticed, although in the aggregate they are quite considerable.

6. From the results of previous studies of this series, as well as the results of the present study, it is believed that severe seminal-root amputations, whether caused by parasitic fungi or by mechanical means, tend to reduce the number of tillers and retard the maturity of the wheat plant. On the other hand, severe artificial amputations of the crown roots hasten the maturity of the plants. In the case of amputations brought about by parasitic fungi, however, both root systems are usually attacked and the reactions of the plants are modified accordingly.

## ACKNOWLEDGMENTS

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## Résumé


**Une comparaison des différents types de pourriture de la racine du blé par l'examen des racines. P. M. Simmonds, R. C. Russell et B. J. Sallans, Laboratoire fédéral de pathologie végétale, Saskatoon, Sask.**

Cette étude porte sur trois types de pourriture qui attaquent la racine du blé; le site de l'attaque et son étendue sur les racines des plantes affectées ont été notés, et des plantes saines qui poussaient dans les mêmes conditions ont été observées et comparées. Il a été constaté que la nature de l'attaque des divers types de pourriture varie beaucoup sous certains rapports, et que les plantes de blé réagissent de façon différente, produisant les différents symptômes complexes caractéristiques de ces trois types de pourriture.

La pourriture commune de la racine (Esp. *Helminthosporium sativum* et *fusarium*) se caractérisait par des lésions brunes sur les entre-nœuds sous-jacents au collet et sur certaines racines vers l'époque ou le blé touchait à la fin de la phase de plantule.

Les tiges et les racines des plantes attaquées étaient un peu rabougries. Vers la mi-saison les lésions étaient plus prononcées sur les entre-nœuds et les racines. Elles étaient présentes également sur les collets et sur les gaines des feuilles de base. Les racines et les tiges paraissaient très rabougries et le développement des épis était retardé. Vers l'époque où les plantes saines étaient à peu près mûres, les lésions graves abondaient sur les parties de la base et surtout sur les entre-nœuds des plantes malades. Racines et tiges, étaient toutes deux très rabougries et le rendement des plantes malades n'a atteint que 70 pour cent de celui des plantes saines.

Le piétin (*Ophiobolus graminis*) se caractérisait par des lésions brun foncé ou noires sur les racines séminales et les entre-nœuds sous-jacents au collet tandis que le blé était encore dans la phase de la plantule. Les racines et les tiges des plantes atteintes étaient rabougries. Vers la mi-saison, le système de racines séminales était presque complètement détruit, la plupart des entre-nœuds sous-jacents au collet étaient noircis et des lésions se remarquaient sur certaines des racines du collet et leurs branches. Les tiges étaient vitement rabougries et seules les plus jeunes feuilles étaient vertes. Vers l'époque où les plantes saines étaient à peu près mûres les racines séminales et les entre-nœuds sous-jacents au collet étaient entièrement morts. Les racines du collet s'étaient développées quelque peu après la pousse de la mi-saison, mais quelques-unes d'entre elles et beaucoup de leurs branches étaient détruites. Les tiges étaient presque complètement blanches et se composaient d'une tige centrale rabougrie et d'un rejeton mort. Les épis étaient rabougris et vides ou partiellement remplis de grains plus ou moins racornis. Le rendement des plantes malades ne se montait qu'à 20 pour cent de celui des plantes saines.

Le champignon de la pourriture brune de la racine (Esp. *Pythium*) a attaqué et détruit en premier lieu beaucoup des petites racines latérales du système de racines séminales. Il a envahi également les pointes végétatives de quelques unes des racines séminales tardives ainsi qu'une grande proportion des racines du collet et les a sectionnées vers la fin de la phase de la plantule. Il en est résulté que la majorité des feuilles sont mortes, les plantes sont devenues très rabougries et la végétation a été presque entièrement interrompue pendant quelque temps. Vers la mi-saison les plantes malades s'étaient remises quelque peu, grâce à la pousse continue des racines séminales et des quelques racines du collet qui avaient échappé à la destruction. Vers l'époque où les plantes saines étaient presque mûres, ni les racines séminales ni les racines du collet des plantes malades n'avaient pris beaucoup de développement. Non seulement les tiges étaient très rabougries mais les épis étaient plus verts et moins mûrs que ceux des plantes saines. Le rendement des plantes malades ne se montait qu'à 20 pour cent de celui des plantes saines.

Les dommages causés à l'hôte par les pourritures de la racines paraissent être à peu près en proportion de la quantité de racines détruites. Les réductions de rendement résultant d'une légère infection de la pourriture de la racine passent souvent inaperçues, quoiqu'elles soient au total très considérables.

A en juger par les résultats des études précédentes sur cette série ainsi que par les résultats de l'étude actuelle, on croit qu'une grave amputation des racines séminales, qu'elle soit causée par le champignon parasite ou par des moyens mécaniques, tend à réduire le nombre des rejetons et à retarder la maturité de la plante de blé. Par contre une grave amputation artificielle des racines du collet précipite la maturité des plantes. Cependant lorsque l'amputation est provoquée par un champignon parasitaire, les deux systèmes de racines sont légèrement attaqués et les réactions des plantes modifiées en conséquences.

# LEAFY SPURGE—*EUPHORBIA ESULA* OR *VIRGATA*[1]

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[Received for publication January 26, 1935]

The weed known popularly in North America as leafy spurge has only in recent years come into special prominence, but is undoubtedly of long-standing occurrence. Both in Manitoba and in North Dakota where its weedy character has been so well demonstrated, there are records of its presence for 25 years or more, and in Minnesota evidently longer. In the east there are older records, one specimen in the National Herbarium of Canada having been collected as early as 1870 near Newburyport, R.I. That the weed should only now be creating alarm is owing probably less to any immediately changing status than to recognition at last of its insidious spread and its tenacity wherever established.

A special interest, for some of us at least, attaches to this plant by reason of recent confusion as to its specific identity. Early collections on this continent had been labelled *Euphorbia Esula* L. A related species, *E. lucida* Waldst. and Kit., was also known from a few localities in the eastern States. Our acquaintance with the first was slight, and with the other *nil*, when in 1924 a rough specimen was received from Brandon, Man., and referred, none too confidently, to the latter species. There was no evidence then at hand that either had been found so far west. The specimen was readily keyed to a choice between these two, and in view of the breadth of most of the bracts subtending the umbel, and some weighing of other points in descriptions which seemed more elaborate than enlightening, the decision was against *Esula*.

Receipt of material from other western points soon raised the issue anew. Search through European collections at the National Herbarium finally disclosed a specimen labelled *E. virgata* Waldst. and Kit., a species which was clearly not to be ignored, though not reported from America. Consultation of the best European works failing to clarify our understanding of these species, the earliest opportunity was taken to appeal to the late Dr. M. O. Malte, then Chief Botanist at the Herbarium, who arrived independently at the conclusion favoured, *i.e.*, that *virgata* was what was being dealt with. In a letter some time later he presented a translation of the characters of *Esula* and *virgata* as taken from an article by the late Prof. Ostenfeld of Copenhagen, and concluded with the statement that "all our specimens are *virgata*. We should be glad to have specimens of *Esula* should you come across it."

In the meanwhile seed of both species had been secured from various Botanic Gardens in the Old World, and roots from Manitoba, North Dakota, Minnesota, and New York, of what was being called *Esula*. From the seeds were grown some spurges not at all referable to either species, and those which were true to name (one name or the other), had not been found distinguishable when the material was discarded. The American roots were grown through a couple of seasons, were evidently of a single species, and according to our interpretation that species would be *virgata*.

[1] Contribution No. 424 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.
[2] Botanist.

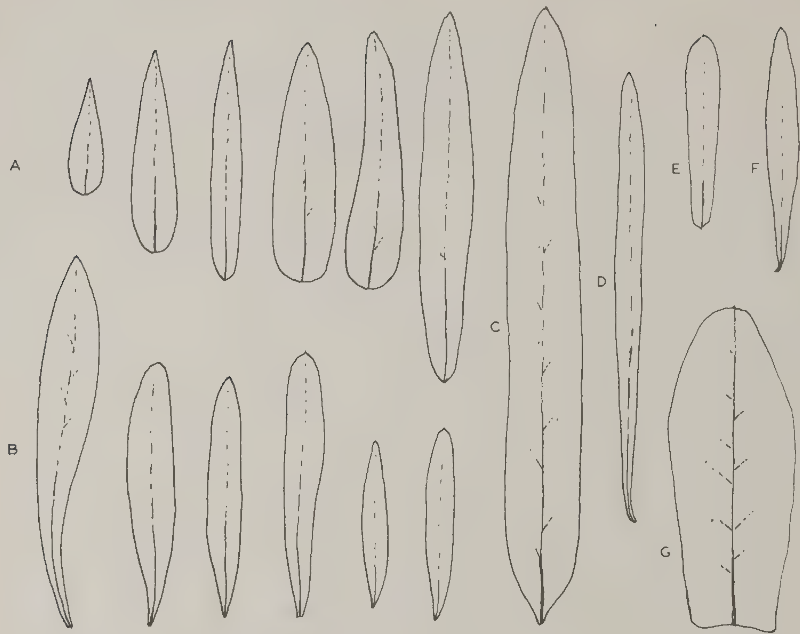


FIGURE 1. Leaf outlines of *Euphorbia* species. (Natural size.) A. *E. virgata* types. Eur. specimens. B. *E. Esula* types. Eur. specimens. C. From vigorous fruiting specimen grown in plot. D. From sterile shoot. E. Specimen with base approaching *E. virgata*, but otherwise unlike it. F. From seedling of four months. G. Broad-leaved Edgerton spurge.

On two different occasions when Dr. H. T. Güssow, Dominion Botanist, has been in Europe, he has sought further light upon the matter, and besides other help, has secured a series of specimens, presumably authentic, of the two species. Incidentally, he has put some of his botanical friends across the water to the test, and has found them not all nor always able to distinguish these far from meagrely described species.

Fine fuel for a "splitter's" and "lumper's" feud one might conclude. But after much hitherto fruitless study of our few European specimens in conjunction with our own larger series, we believe we are able at last to seize upon diagnostic characters with enough consistency for practical use. Having found them, it can be seen where they might be somewhat implied, though nowhere very clearly stated, in descriptions at hand. Unfortunately the original description of *virgata* has not been available, and may be clearer at this point than are Linnaeus' characterization of *Esula*, and later works.

In the descriptions and keys gathered from numerous sources, much has been made of the shape of the leaves, which in our experience is a character anything but constant. For instance: "We distinguish *E. Esula* from *E. virgata* by the shape of the leaves. The leaves of *virgata* are broadest below the middle—those of *Esula* are linear or broadest above the middle." (Translation from letter to Dr. Güssow from Prof. Dr. Karl

Fussengath, Munich Botanic Garden.) The concept here presented is of the whole leaf. If instead, attention were directed to the point of attachment to the stem the essential feature of the leaf shape would seem to be better stressed (See figure). In *Esula* the allegedly, but not always actually, narrower lower portion of the leaf does usually become attenuate to a little petiolate at base. In *virgata* this sometimes broader lower portion is carried through to a rounded, sessile, almost clasping base in many examples. Many leaves in this respect however, could belong to either. The actual outline depends somewhat on the breadth of the leaf, which may not be the same on all parts of the stem, and is commonly less on sterile shoots and on seedling plants. Basal leaf shape is at least a more constant and tangible feature than general outline.

Having regard then to this simple matter of leaf attachment little difficulty was found in sorting our European specimens in accordance with their labels, and then in referring the 50 or so American specimens seen (when adequate for identification), to *Esula*. In only one or two cases did a plant approximate the *virgata* type of leaf base at all closely. The European plant in the National Herbarium, moreover, which has passed as *virgata*, and in so doing helped to mislead us earlier, also conforms to this conception of *Esula*.

With this as a fresh point of departure it is proving easier to correlate other characters which alone had not been striking enough or constant enough to be very helpful. Thus, in the matter of texture, it appears that leaves of *virgata* possess a firmness, and with it a pale, somewhat olive green colour, approached sometimes by plants from the drier west, but seldom by eastern plants or those grown in the east from western material. The leaves subtending the umbel are frequently, but not always narrower in *Esula*, as commonly stated. The inflorescence appears to be more umbellate in *Esula*, and thyrsoid in *virgata*, owing to more scattered branching below the umbel and fewer rays within it, in the latter; but much depends upon the stage of development. Other criteria doubtless have value if carefully studied in enough specimens, or with the advantage of field acquaintance with both species, which we lack. Herbarium material does not indicate relative height, which is said to be greater in *virgata;* nor does it convey much idea of the root-stock, which we know is distinctly spreading in our leafy spurge, but is described as more descending in *virgata*.

In the uncertainty that has arisen, it has seemed possible that both species of *Euphorbia* were present, but it is evident that only *Esula* is represented in material studied here obtained from both east and west. *E. lucida*, referred to above, is not known apparently in Canada, but a variety of it may be here. A decidedly broad-leaved spurge (See figure), infesting a field near Edgerton, Alta., and first reported in 1933, was submitted to the Gray Herbarium, Harvard University, but lacking fully mature fruit, is still only tentatively identified as such. It has all the weedy propensities of the better known leafy spurge.

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NOTE.—Since the foregoing went to press, field work near Greenstreet, north east of Lloydminster, Sask., on June 21st located a spurge which answers in all particulars which could be checked in the field to *Euphorbia virgata;* and provides strikingly in two considerable patches, field impressions of difference from *E. Esula*, which we have lacked in herbarium material.

# MINERALOGICAL AND CHEMICAL STUDIES ON SOME OF THE INORGANIC PHOSPHORUS COMPOUNDS IN THE SOIL[1]

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Our knowledge of the inorganic phosphates in soils includes a definite recognition of the occurrence of apatite and the assumption, with some supporting evidence, of iron phosphates the exact nature of which is in considerable doubt. The purpose of this investigation was to learn more about the inorganic phosphates occurring in soils. Commencing with the tentative hypothesis that the formation of secondary crystalline phosphate minerals might be involved in phosphorus fixation and availability, it was decided that the first objective should be the identification of such crystalline phosphate minerals as might occur in soils. The work was, therefore, largely mineralogical although some chemical studies were made.

## Previous Work

A review of the literature shows that although there has been considerable speculation regarding the inorganic phosphorus compounds in the soil, little is known as regards their exact composition or properties. The only phosphorus minerals that have been identified in soils are apatite, vivianite, monazite, and turquoise. These minerals, with the exception of apatite, must be of rare occurrence since monazite and turquoise are rare phosphates, and vivianite being a ferrous phosphate could not persist in a normal, well aerated soil. The work of McCaughey and Fry (*9*), Plummer (*10*) and others shows that apatite commonly occurs. Little is known about other inorganic phosphorus compounds in the soil (*3*).

While past mineralogical researches upon soils have failed to show the presence of secondary crystalline phosphate minerals this does not mean, necessarily, that such minerals are not present, since the researches were made on the sand and coarse silt fractions, whose particles may be larger than are those of these phosphate minerals. Because no attempt beyond separating the quartz grains from the other minerals has been made in concentrating the phosphate minerals the detection and identification of such minerals would be difficult on account of the mass of other minerals present.

Recent improvements in immersion methods by Emmons (*3*) have made possible the identification of smaller mineral particles than was formerly the case. Mineral grains that are too small or too opaque to be identified by the Emmons double variation method can be identified by means of X-ray patterns if the sample is fairly pure. It seemed possible, therefore, that further information might be contributed if the phosphate minerals in the soil were sufficiently concentrated to make studies by these methods feasible.

## Mechanical Separation According to Texture or Size of Grains

The soil was dispersed according to methods used in the Soils Department at Wisconsin. The soil was digested for one hour on a steam bath with normal sodium chloride solution, then filtered on a Buchner funnel

[1] This paper was constructed from a thesis submitted to the University of Wisconsin in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

[2] Lecturer of Soils.

and washed with 6% sodium chloride solution until the leachate gave no test for calcium. The excess sodium chloride was then washed out, the sample placed in distilled water and dispersed with a dispersion apparatus arranged according to Bouyoucos (*1*). Various methods were tried for the removal of the fine clay from the sample and since the sample was necessarily large and the separation was qualitative, it was found that the most satisfactory method was by settling in large vessels and decanting the suspended clay. After the removal of the fine clay the sands were easily removed by sieving.

Considerable amounts of colloidal material adhere to the silt grains even after this treatment and can only be removed by rubbing. While desirable, it is not essential that the silt grains be entirely cleaned before making specific gravity separations but it is essential that loose fine clay be removed since such material separates with difficulty.

### Separation According to Specific Gravity of the Grains

The heavy liquids used in the separation of the minerals in the silt and coarse clay fraction of the soil were s-tetra-bromethane and Clerici solution, the former being used to separate the quartz, feldspar, and other minerals of specific gravity less than 2.9, and the latter to separate the minerals having a greater specific gravity. The separation was carried out by placing the sample in the heavy liquid of desired specific gravity, evacuating to remove air films around the grains and then centrifuging. This procedure will be given in more detail later.

Symmetrical tetrabromethane is a very satisfactory heavy liquid to use when a specific gravity of 2.95 or less is required. Its density is not appreciably altered by evacuating or by centrifuging, and its density can be easily lowered by the addition of nitrobenzene. Volk (*19*) has made a critical study of the use of this liquid in mineral separations.

Clerici solution was selected because it can be used successfully to make separations up to specific gravity of 4.0. This solution is prepared by dissolving equal quantities of thallium malonate ($CH_2(COOTl)_2$) and thallium formate ($HCOOTl$) in water. These salts may be purchased from the Eastman Kodak Company or they may be prepared according to the method reported by Vassar (*17*) or Vhay and Williamson (*18*). This solution is in some ways a convenient heavy liquid to use. Its specific gravity is easily changed by the evaporation or addition of water, it has a low thermal coefficient of expansion, and if a refractometer is available its density is easily determined since the relation between its specific gravity and refractive index is a linear one. Clerici solution has one serious disadvantage in that even slight losses of water will markedly affect its density at high gravities. The high vapor pressure of the solution makes it very difficult to prevent any loss of water during the process of separation of the minerals. The experimental results in Table 1 on following page indicate that serious errors will occur unless precautions are taken.

Another disadvantage of Clerici solution is that even a slight contamination with acids or organic liquids, such as acetone, will cause thallium salts to precipitate thus impairing if not destroying the value of the solution.

The necessity of centrifuging and evacuating has been pointed out by previous investigators. McCaughey and Fry (*9*) in 1913 mentioned the importance of the centrifuge in the separation of fine grains, and later

TABLE 1.—CHANGES IN SPECIFIC GRAVITY OF CLERICI SOLUTION DUE TO EVAPORATION OF WATER

| Condition of exposure or treatment | Time of treatment | Temp. of treatment | Sp. Gr. before treatment | Sp. Gr. after treatment | Increase in Sp. Gr. |
|---|---|---|---|---|---|
| In a 150 cc. beaker, uncovered | 2 hrs. | 25° C. | 3.17 | 3.31 | 0.14 |
| In a 150 cc. beaker, uncovered | 41 hrs. | 25° C. | 3.14 | 3.94 | 0.80 |
| Centrifuging in 50 cc. tube | 12 min. | 25° C. | 3.24 | 3.30 | 0.06 |
| Evacuation with vacuum pump—10 cc. solution in 50 cc. tube | 2 min. | 25° C. | 3.12 | 3.17 | 0.05 |

Brown (*2*) showed that quantitative results could be obtained by its use. Emmons (*3*) points out the necessity of removing the air film that adheres to each mineral particle so that the liquid can come into direct contact with it. He further reports that a good separation was obtained by evacuation alone but the writer was not able to confirm his results. To obtain best results a combination of the two methods is advisable.

The outline of the method which gave the best results with tetrabromethane and, after a few modifications, with Clerici solution follows. A small sample was placed in a centrifuge tube with the liquid of desired density, then evacuated and then centrifuged for about five minutes, running the centrifuge slowly at first and gradually increasing its speed to 1000 r.p.m. This treatment resulted in a clear-cut separation, the lighter minerals being found on the surface of the liquid and the heavier ones in the bottom of the tube. By using liquids of different densities it was thus possible to separate the sample into different minerals or groups of minerals.

Satisfactory and accurate separations were made with Clerici solution by modifying the procedure somewhat. The entire sample was evacuated in the presence of Clerici solution of the approximate density of that to be used for the separation. Further evacuation at any stage in the separation was rendered unnecessary by keeping the sample moist with the solution. The very small amount of liquid retained by the grains when transferred to a large volume of solution of slightly different density was not enough to appreciably affect the density of the liquid to which the sample had been added. Corking the tubes tightly prevented any change in specific gravity during centrifuging.

## Methods of Chemical Analysis

The methods of chemical analysis employed were those regularly in use at the Soils Department of the University of Wisconsin. Wherever possible total phosphorus was determined colorimetrically by fusing the sample with sodium carbonate and extracting with water according to the method developed by Truog and Rothermel[3] and then determining the phosphorus directly by the colorimetric method as described by Truog and Meyer (*16*). The phosphorus in the acid extracts was determined volumetrically rather than colorimetrically because the large amount of ferric iron present would have interfered with the latter procedure.

[3] Unpublished work.

The combined $H_2O$ was taken to be the loss upon ignition after drying the sample at 130° C. This method being an indirect one gives only approximately correct results.

The use of the micro-chemical test for phosphorus as described by Wiley (*20*) and others proved of much assistance in detecting the phosphorus bearing compounds with the microscope. Some phosphates are, however, so insoluble as to invalidate the test.

Four soils were studied, namely a Miami silt loam from near Madison, Wisconsin, rather low in total phosphorus; a silt loam from the limestone region of Kentucky, high in total phosphorus, hereafter called the Lexington sample; an iron rich, very acid alluvial soil from Wisconsin, high in total phosphorus; a podsol soil from central Alberta, low in total phosphorus.

## Distribution of Phosphorus in Different Specific Gravity Separates

The results of the specific gravity separations and of the phosphorus analyses of the various separates for the Miami and the Lexington samples are given in Tables 2, 3 and 4. The data in Tables 2 and 3 are for the silt and coarse clay fraction, those in Table 4 for the entire soil less the fine clay and the light sand fractions. The term light is used to designate those minerals or separates having a lower specific gravity than 2.70 and the term heavy for those having a higher specific gravity than 2.70.

The data show that while in no instance was the phosphorus entirely removed from any separate it was concentrated to a much greater extent in some separates than in the others. This fact indicates that at least some of the phosphorus in these soils occurs in minerals of a definite specific gravity.

TABLE 2.—AMOUNTS OF DIFFERENT SPECIFIC GRAVITY SEPARATES IN SILT FRACTION OF MIAMI SILT LOAM AND PERCENTAGES AND AMOUNTS OF PHOSPHORUS IN THESE SEPARATES

| Separate | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| Sp. Gr. range of separate | 2.55–2.69 | 2.69–2.95 | 2.95–3.14 | 3.14–3.24 | 3.24–3.34 | 3.34–3.48 | 3.48–up |
| Amount in grams | 99.3 | 0.71 | 0.32 | 0.28 | 0.28 | 0.62 | 1.24 |
| Percent phosphorus in separate | 0.011 | 0.068 | 0.038 | 0.063 | 0.10 | 0.038 | 0.240 |
| Amount of phosphorus in mgs. in separate | 10.90 | 0.28 | 0.12 | 0.18 | 0.28 | 0.24 | 2.98 |

TABLE 3.—AMOUNTS OF DIFFERENT SPECIFIC GRAVITY SEPARATES IN SILT FRACTION OF LEXINGTON SILT LOAM AND PERCENTAGES AND AMOUNTS OF PHOSPHORUS IN THESE SEPARATES

| Separate | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| Sp. Gr. range of separate | 2.56–2.70 | 2.70–3.16 | 3.16–3.38 | 3.38–3.52 | 3.52–3.66 | 3.66–3.91 | 3.91–up |
| Amount in grams | 440 | 10.4 | 3.16 | 2.85 | 1.19 | 2.48 | 4.87 |
| Percent phosphorus in separate | 0.112 | 1.15 | 4.46 | 1.40 | 1.75 | 1.25 | 0.80 |
| Amount of phosphorus in mgs. in separate | 493 | 120 | 141 | 39.6 | 20.8 | 31.0 | 39.0 |

TABLE 4.—AMOUNTS OF SILT AND HEAVY SAND FRACTIONS OF LEXINGTON SILT LOAM AND PERCENTAGES AND AMOUNTS OF PHOSPHORUS IN THESE SEPARATES

| Separate | 1 | 2 | 3 |
|---|---|---|---|
| Texture of separates | Silt | Silt | Sand |
| Sp. Gr. of separates | <2.7 | >2.7 | > 2.7 |
| Weight of separate in grams | 450 | 25 | 36 |
| Percent phosphorus in separate | 0.112 | 1.56 | 3.0 |
| Amount phosphorus in mgs. in separate | 504 | 390 | 1080 |

The Miami silt loam contains in the silt fraction only a small amount of heavy minerals, 97% of the sample being light minerals. The percentage of phosphorus in the heavy minerals is considerably higher than in the light minerals, but the total amount of phosphorus is much greater in the latter. An appreciable concentration of phosphorus occurs in the separate having a greater specific gravity than 3.48, this separate comprising less than 1.25% of the total sample containing about 20% of the total phosphorus in the sample.

The Lexington silt loam has a higher proportion of heavy minerals in the silt fraction. The concentration of phosphorus in the heavier minerals is many times as great as in the lighter minerals, the highest concentration occurring in the specific gravity of 3.16–3.38.

An examination of the sand fraction of the Lexington sample showed that a considerable portion was composed of dark brown to black grains which upon crushing appeared to be composed of fine particles of iron oxide cemented together. Most of these grains gave a strong test for phosphorus. Since these grains had a specific gravity greater than 2.70 they were easily separated from the remainder of the sand which consisted of quartz grains. As is shown in Table 4 this heavy sand fraction contained more phosphorus than the silt fraction. True, this coarse separate proved to be fine grained material cemented together, but in an ordinary mechanical analysis it would be classed with the sand fraction.

A partial separation of the Wisconsin alluvial soil showed that nearly all the phosphorus was present in the specific gravity separates above 3.30. These separates appeared to be composed entirely of reddish iron oxide, but analysis showed that they contained 2.7% phosphorus.

### Presence of Calcium Phosphate Minerals in Soils

Microscopic examination of separate C (Sp. Gr. 3.16–3.38) of Lexington silt loam showed the presence in considerable amounts of a phosphate mineral. This mineral was, in general, isotropic but sometimes showed weak double refraction. The indices of a number of these grains as read by the Double Variation method gave an average value of 1.623 for sodium light. The general appearance of this mineral, its isotropic nature, refractive index, easy solution in acid, and the strong test it gave for phosphorus agreed with the description of the mineral collophane ($Ca_3P_2O_8.H_2O$). Direct comparison made with a museum specimen of collophane provided further proof. Rogers (*11*) states that the specific gravity of collophane ranges from 2.6–2.9. However, evidence exists that Rogers is too low in his upper limit. A specific gravity determination on a sample of collophane obtained from Rogers showed that more than half the

sample had a specific gravity greater than 2.9. Also a recent paper by Martens (*8*) points out that most of the collophane he was working with sank readily in a liquid with a density of 2.85.

Collophane was found in separate B of the Lexington sample but it was not found in any of the separates whose specific gravities were greater than 3.38. No other calcium phosphate minerals were found in this soil.

There is little doubt but that the collophane in the Lexington soil is a residual mineral left from the weathering of the parent limestone rock. Calcium phosphates are supposed to weather quite rapidly but because of the abundance of collophane in this soil it would seem that at least certain varieties are fairly resistant. The mineral apatite ($Ca_5(F, Cl) P_3O_{12}$) is also supposed to be easily soluble and yet it has been found in many soils. A study of the leached layer (*7*) of an Alberta podsol showed the presence of fresh grains of apatite which indicates that certain apatites can resist even severe weathering for a considerable time. McCaughey and Fry (*9*) noted that the apatite found in soils was invariably the fluor variety and by analogy it would seem that the collophane found in soils may be the fluor collophane.

## Presence of Iron Phosphates in Soils

Micro-chemical examination indicated that there were at least two phosphorus compounds in the heavier specific gravity separates of these soils, one readily soluble in acid solution and one comparatively insoluble. Both of these phosphorus compounds were in brown to black opaque grains which did not exhibit any crystalline properties. Since such compounds could not be identified with the microscope, it was necessary to resort to X-ray and chemical properties.

A study of the Lexington separate 3 (see Table 4) and the heavier separates of the Wisconsin alluvial soil showed that both these phosphorus compounds were present. Since there were much more of these separates available than of any of the other separates containing these compounds, further study was confined to them.

Efforts to concentrate the phosphorus bearing compounds in separate 3 of the Lexington soil by specific gravity separations resulted in failure. Even after the removal of the easily soluble phosphorus compound no concentration could be obtained as Table 5 shows.

TABLE 5.—PHOSPHORUS CONTENT OF THE HEAVY SPECIFIC GRAVITY SEPARATES OF LEXINGTON SAND AFTER TREATMENT WITH 1 PER CENT (BY VOLUME) SULPHURIC ACID

| Separate | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Range in Sp. Gr. | 3.1 – 3.41 | 3.41– 3.50 | 3.50– 3.66 | 3.66– 3.75 | 3.75– 4 | 4– up |
| Per cent phosphorus | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.12 |

The even distribution of the phosphorus throughout indicated that the phosphorus compound or compounds were present in intimate association with other grains and were not present as discrete grains or crystals.

Each of the above separates and a sample of the untreated material was X-rayed. The results showed that the only crystalline substance

present in any of the separates was quartz. This meant that the other compounds present were amorphous. The reason quartz was found in this separate may be due to its presence as tiny crystals that were coated with so much iron oxide that as regards specific gravity deportment they did not behave according to their own specific gravity.

No attempts were made to further concentrate the heavy separate of the Wisconsin alluvial soil, as nearly all the grains gave a strong test for phosphorus. No crystalline minerals could be detected and X-ray analysis showed that this material was amorphous.

## Solubility of the Iron Phosphates in Soils

It has previously been pointed out that the fundamental thesis of this investigation was to discover and identify the crystalline phosphate minerals in the soil. However, after the failure to find any crystalline minerals in the iron rich high phosphorus separates of three soils it was thought well to digress from this thesis and to endeavor to find by chemical methods the composition of the phosphates present in these separates.

A fairly complete total analysis was made of the Lexington separate after treating with 1% sulphuric acid to remove the easily soluble phosphorus compounds. This was done in order to determine the possible bases with which the phosphorus might be in combination. The analyses showed that the phosphorus must be in combination with iron or aluminum, as no other base was found to be present. The presence of quartz as shown by the X-ray analysis previously mentioned was verified by the analyses.

When the Lexington sample was treated with 1% sulphuric acid a considerable amount of iron was brought into solution. Tests were made on a number of iron oxides to determine their solubility in acid treatments. Hematite, Turgite, Goethite, and limonite were slightly soluble at 86° C. but at 26° they were practically insoluble except some samples of limonite which were partly soluble in all strengths of sulphuric acid from 1 to 20%. The fact that some limonites were partly soluble while others were not was a puzzling one until it was discovered that phosphorus was always present in the extracts from the soluble ones. The conclusion was drawn that pure limonite is practically insoluble in cold acid and that any appreciable solubility is due to the presence of soluble iron phosphates. Roscoe and Schorlemmer (*12*) point out that basic iron phosphates occur in nature frequently as a constituent of limonite. It appears safe to assume as a result of this work that practically all the iron dissolved by the acid extractions of the heavy separate was in combination with phosphorus.

Samples of the Lexington heavy separate 3 (Table 4), limonite that showed soluble iron, and the heavy separate of the Wisconsin alluvial soil, were treated with different strengths of sulphuric acid at room temperature (25° C.). The relative amounts of $Fe_2O_3$, $Al_2O_3$, $P_2O_5$ and combined water extracted from these samples by this treatment, expressed on the basis of $P_2O_5$ equals 100, are shown in Table 6. Analysis of the residue showed that all the phosphorus was extracted from the alluvial sample but only about half of it from the Lexington sample. The limonite residue was not analyzed.

TABLE 6.—ANALYSES OF SULPHURIC ACID EXTRACTS OF LEXINGTON HEAVY SAND FRACTION, LIMONITE, AND HEAVY FRACTION OF WISCONSIN ALLUVIAL SOIL

Expressed as comparative weights $-P_2O_5 = 100$

| Sample | Lexington | Limonite | Wisconsin alluvial |
|---|---|---|---|
| Time of treatment | 24 hrs. | 24 hrs. | 2 hrs. |
| Strength of acid | 1% by vol. | 1% by vol. | 5% by vol. |
| $Fe_2O_3$ | 289 | 441 | 800 |
| $Al_2O_3$ | 136 | None | None |
| $P_2O_5$ | 100 | 100 | 100 |
| $H_2O$ | 164 | 128 | 205 |

The data in Table 6 show that phosphorus is combined with iron and possibly aluminum, forming highly hydrated phosphates. The iron extracted from the treated samples was all in the ferric state.

Assuming in the case of the Lexington separate that the aluminum as well as the iron is in combination with the phosphorus, although it may have come from other aluminum compounds in this separate as the solubility of such compounds with this treatment is not known, a compilation of the analyses of the acid extracts gives the molecular ratio of the oxides believed to be in combination with the phosphorus as follows:—

| | |
|---|---|
| Lexington separate—1% acid | $4.5R_20_3.P_2O_5.13H_2O$ |
| Limonite sample—1% acid | $4FE_2O_3.P_2O_5.10H_2O$ |
| Wisconsin alluvial separate—5% acid | $7Fe_2O_3.P_2O_5.16H_2O$ |

From the above ratios and the fact that all the phosphorus was extracted by 5% acid, but only about half by 1% acid, it would seem that the more basic the phosphate the more insoluble it is.

C. W. Stoddart (*15*) stated that it is commonly assumed that the iron phosphate mineral in soils is the basic iron phosphate Dufrenite ($Fe_2(OH)_3.PO_4$). The investigations reported in this paper have been limited in number and in scope but from the results so far obtained this assumption is not substantiated. The evidence shows that crystalline iron phosphates are not formed in soils and that the iron phosphates found there are more basic than any phosphorus mineral so far reported.

Russell (*14*) points out that it is remarkable that X-ray analyses of colloidal clay have failed to show the presence of limonite or hematite. The investigations reported in this paper show that the iron oxides present in soils are amorphous.

## SUMMARY

Some of the phosphates in several soils were studied by mineralogical and chemical methods. A mineralogical method adopted for the concentration of inorganic soil phosphates, based on specific gravity separation did not result in the complete isolation of such phosphates but appears to be the best means of accomplishing their concentration. The use of the petrographic microscope in identifying soil phosphates is limited because the secondary phosphates appear to be amorphous. The phosphorus of the soil is not confined to any particular specific gravity portion. It is, however, concentrated to a large extent in the heavy fractions and more particularly in certain portions of these fractions.

The calcium phosphate minerals apatite and collophane were found in relative abundance in a certain few soils. They are believed to be

primary minerals; that is, they have not been formed in the soil. The secondary phosphates of iron and aluminum found in the soils studied are amorphous. Such phosphates have a complex chemical composition and are highly hydrated. Iron oxides found in the soil were also amorphous.

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## Résumé


**Etudes minéralogiques et chimiques de quelques-uns des composés inorganiques de phosphore dans le sol. A. Leahey, Université de l'Alberta, Edmonton, Alberta.**

Quelques-uns des phosphates dans plusieurs sols différents ont été étudiés au moyen de procédés minéralogiques et chimiques. Un procédé minéralogique adopté pour la concentration des phosphates inorganiques du sol, basé sur la séparation par pesanteur spécifique, n'a pas réussi à isoler complètement ces phosphates, mais il semble que ce soit le meilleur moyen de réaliser leur concentration. L'emploi du microscope pétrographique pour identifier les phosphates du sol est limité, parce que les phosphates secondaires paraissent être amorphes. Le phosphore du sol n'est pas limité à une portion spéciale de pesanteur spécifique, mais il est concentré dans une large mesure dans les fractions lourdes et spécialement dans certaines parties de ces fractions. Les minéraux de phosphate de calcium, apatite et collophane, ont été trouvés en abondance relative dans certains sols. On croit que ce sont des minéraux d'origine primaire, c'est-à-dire qu'ils ne se sont pas formés dans la terre. Les phosphates secondaires de fer et d'aluminium trouvés dans les sols étudiés sont amorphes. Ces phosphates ont une composition chimique complexe et sont fortement hydratés. Les oxydes de fer trouvés dans le sol étaient également amorphes.

# THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA

Vol. V, No. 2. June, 1935


## THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index of wholesale prices in Canada advanced from 72.0 in March to 72.5 in April. The vegetable products index rose from 67.5 to 69.4. Non-ferrous metals and their products showed a similar gain from 65.2 to 67.9. There was also a slight advance in the index of prices of wood, wood products and paper. These three factors more than offset losses in other groups and resulted in a rise of a half point in the total index.

Wholesale price levels in other countries within the sterling and gold "blocs" declined moderately during the first quarter of 1935 according to a statement recently issued by the Internal Trade Branch of the Dominion Bureau of Statistics.

Retail prices in Canada were slightly lower than in March, the index receding to 78.8 because of a decline in retail prices of foods.

***Physical Volume of Business.***—The index of the physical volume of business regained much of the loss recorded in March, the April index being 98.3 compared with 94.2 in the previous month. Industrial production was also higher in April, rising to 97.7. Mineral production advanced from 143.4 to 156.4. Exports of nickel were lower but shipments of gold, silver and copper were substantially higher. There was also a marked increase in the production of lead.

In the manufacturing group increased activity was quite marked and the index rose from 86.8 in March to 94.0 in April. Flour production advanced from 72.5 to 82.6. Manufacture of sugar, exports of cheese and canned salmon were well above the volume reported in March.

The forestry index also showed a gain largely because of increased exports of newsprint, wood pulp and shingles. The index of iron and steel production showed a moderate gain, rising from 90.2 to 92.2. Automobile production was slightly below the peak recorded in March. Construction continues at very low levels, the April index being below that for March. Car loadings showed a slight gain. Both exports and imports were higher than in the previous month. The index of grain and live stock marketings advanced from 65.4 to 91.8. Grain marketings were substantially higher but shipments of live stock were lower. Cold storage holdings fell from 143.2 to 135.8.

***Agricultural Products.***—The index of wholesale prices of Canadian farm products rose from 62.7 to 64.7. This gain was due to improvement in the prices of field products which index advanced from 56.4 to 59.8. The average price of No. 1 Manitoba northern wheat was 87.6 cents per bushel in April, basis Fort William and Port Arthur compared with 81.9 cents in March. Prices of barley, oats, rye and flax were also higher. Moisture conditions are much more satisfactory in Western Canada than a year ago but cold weather has delayed seeding and retarded growth in all sections of the country.

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913 | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | | | | |
| 1914 | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | | | | |
| 1915 | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | | | | |
| 1916 | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | | | | |
| 1917 | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | | | | |
| 1918 | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | | | | |
| 1919 | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920 | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921 | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922 | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.8 |
| 1923 | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.6 |
| 1924 | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.9 |
| 1925 | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.6 |
| 1926 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1927 | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928 | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929 | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930 | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931 | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932 | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | 67.1 | 51.0 | 45.8 | 59.6 | 77.7 | 79.7 | 76.8 | 105.1 | 115.4 |
| 1934 | 71.6 | 59.0 | 53.9 | 67.6 | 78.9 | 94.2 | 93.6 | 88.5 | 114.2 |
| 1934 | | | | | | | | | |
| Jan. | 70.6 | 55.3 | 47.9 | 67.8 | 78.2 | 86.8 | 84.5 | 48.2 | 108.1 |
| Feb. | 72.1 | 58.0 | 49.3 | 72.5 | 78.7 | 86.4 | 84.0 | 67.1 | 98.6 |
| Mar. | 72.0 | 56.5 | 49.5 | 68.3 | 79.9 | 93.1 | 92.0 | 63.8 | 97.0 |
| Apr. | 71.1 | 55.4 | 48.7 | 66.6 | 79.4 | 92.6 | 91.4 | 56.9 | 94.5 |
| May | 71.1 | 56.9 | 51.1 | 66.5 | 78.5 | 99.6 | 99.4 | 130.6 | 102.6 |
| June | 72.1 | 59.3 | 55.5 | 65.6 | 78.2 | 95.8 | 95.2 | 97.2 | 126.1 |
| July | 72.0 | 60.0 | 57.8 | 63.7 | 78.4 | 95.7 | 95.6 | 148.8 | 116.3 |
| Aug. | 72.3 | 61.6 | 60.7 | 63.1 | 78.7 | 99.0 | 99.8 | 172.8 | 114.7 |
| Sept. | 72.0 | 61.3 | 58.9 | 65.3 | 79.0 | 97.1 | 97.5 | 127.7 | 117.7 |
| Oct. | 71.4 | 60.9 | 55.3 | 70.4 | 79.3 | 95.8 | 95.3 | 61.2 | 128.8 |
| Nov. | 71.2 | 61.2 | 55.7 | 70.4 | 79.4 | 96.5 | 97.0 | 51.2 | 130.4 |
| Dec. | 71.2 | 61.6 | 56.0 | 70.9 | 79.0 | 92.4 | 91.0 | 36.0 | 135.7 |
| 1935 | | | | | | | | | |
| Jan. | 71.5 | 61.4 | 55.7 | 71.0 | 78.9 | 97.5 | 97.8 | 30.6 | 143.7 |
| Feb. | 71.9 | 62.0 | 55.7 | 72.6 | 79.1 | 100.6 | 101.1 | 62.2 | 141.2 |
| Mar. | 72.0 | 62.7 | 56.4 | 73.3 | 79.0 | 94.2 | 93.3 | 65.4 | 143.2 |
| Apr. | 72.5 | 64.7 | 59.8 | 72.9 | 78.8 | 98.3 | 97.7 | 91.8 | 135.8 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1932, p. 15.
2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1932, p. 32, and Monthly Mimeographs 1933 and 1934.
3. Wholesale prices of grains, fruits and vegetables.
4. Wholesale prices of Animals and Animal Products.
5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.
Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs, 1933-1934.
6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical Volume of Business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

The report on farmers' intentions to plant issued by the Agricultural Branch of the Dominion Bureau of Statistics indicates that there will be a reduction of 3% in the acreage of spring wheat in 1935. This is the third successive year in which a reduction has been reported but it is not as large as in 1933 or 1934. Most of the

reduction is in Saskatchewan where it amounts to 4%. On the other hand, intended acreage of oats will be 4% higher and that of barley will be 5% larger than in 1934. Farmers' intentions to plant potatoes indicate a reduction of 8% chiefly in the Maritime Provinces.

The index of prices of animal products receded from 73.3 to 72.9. Prices of eggs and calves were lower. Cattle prices were higher early in the month but were lower towards the end, reflecting conditions in United States markets. Hog prices advanced throughout April, and lambs sold at better prices on all markets except Toronto where heavy receipts from Western Canada were responsible for a recession.

Exports of cattle to United States to May 16 were 63,893 head. Sales of cattle at public markets to the foregoing date were 359,983 head compared with 415,212 head during the same period in 1934. Sales of calves were 133,969 and 313,644 respectively. Shipments of sheep were 76,116 and 70,900 during the same periods and hog gradings 1,236,768 in the first twenty weeks of 1935 against 1,286,060 during the first twenty weeks of 1934. Exports of bacon and hams to the United Kingdom during the twelve months ending March 31, 1935, were 1,270,529 hundredweight, compared with 945,597 hundredweight in the year ending March 31, 1934.

Production of butter during the first three months of 1935 compared with the same period in 1934 showed a decrease of 8.8%. The most marked regional decline took place in the Maritime Provinces. In Quebec on the other hand, there was an increase of 3.5%. British Columbia had an increase of 1.9%. There were decreases of 15.8 and 14.0% in Saskatchewan and Alberta, and Ontario showed a decrease of 5.8%. Total output was 23,660,171 pounds compared with 25,932,258 pounds in the first three months of 1934.

There was a slight increase in the number of boxes of cheese graded during the period December 3, 1934, to April 27, 1935, the total being 44,007 compared with 41,904 during a similar period ending April 28, 1934.

## FARM ASSESSMENT IN QUEBEC[1]

S. C. Hudson[2]

Since taxes in rural municipalities are, for the most part, levied on the basis of real property, the major responsibility for an equitable distribution of the burden of municipal taxation rests with the assessors who evaluate the holdings of the individual taxpayer. Although such taxes are levied on real estate rather than income, it should be remembered that they must be paid in the long run, if at all, from income. The assessment of the farm then, if it is to be satisfactory, must reflect the productive capacity of that farm as measured by farm income.

The relation of farm taxes to farm income on a number of farms in the Province of Quebec is presented in Table 1. In this table, records of some 84 farms businesses were sorted on the basis of farm income and the farm taxes expressed as a percentage of the farm income for each group. The fact that farmers having incomes of less than $1,000 paid over 33% of their incomes in taxes, while those having incomes of $3,000 or more paid less than 3% of their incomes to their municipalities indicates that under the existing system, farmers with low incomes are taxed more heavily than those with large incomes. While it may be that some farmers received low incomes due to misfortune or poor management, it would seem that further study of assessment and factors affecting its accuracy would be helpful.

In an attempt to study the accuracy of the assessment of individual farms in a number of rural municipalities in Quebec, the assessed valuations of 84 farms for which farm management records were available were obtained from the respective

[1] This study was conducted in co-operation with the Department of Farm Economics, Macdonald College, P.Q., and is a preliminary statement subject to revision and correction.
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TABLE 1.—RELATION OF FARM INCOME TO FARM TAXES ON 84 QUEBEC FARMS

| Farm income | Number of farms | Farm taxes in per cent of farm income |
|---|---|---|
| $ | | |
| Minus income | 19 | — |
| 0–1,000 | 37 | 23.5 |
| 1,000–2,000 | 16 | 11.5 |
| 2,000–3,000 | 8 | 5.4 |
| 3,000 and over | 4 | 2.9 |
| Totals | 84 | 13.8 |

municipal clerks and compared with the farm value as estimated by the farm operator in collaboration with an experienced farm management investigator. A frequency distribution of these farms according to the ratio of assessed to estimated value is presented in Table 2. While considerable variation may be noted in the assessment practices in different municipalities, the average assessment ratio varying from about 20 to 60% of the estimated value, the variation in the assessment ratios of individual farms within each municipality is of much greater consequence.

The results of this variation in assessment may be noted in Table 3 in which the farms are grouped according to their estimated value. While farms valued under \$1,000 were assessed on the average at 48.2% of their estimated value, those valued at from \$10,000 up to \$20,000 had an average assessment ratio of 37.7% and those valued at \$20,000 and over were assessed at 30.1%. That is, low-valued farms are over-assessed and thus over-taxed relative to those of higher value.

TABLE 2.—FREQUENCY DISTRIBUTION OF SOME QUEBEC FARMS ON THE BASIS OF THE RATIO OF ASSESSED TO ESTIMATED VALUATION

| Class interval | Twp. No. 1 | Twp. No. 2 | Twp. No. 3 | Twp. No. 4 | Twp. No. 5 | Twp. No. 6 | Totals |
|---|---|---|---|---|---|---|---|
| 5– 10 | – | 1 | – | – | – | – | 1 |
| 10– 15 | – | – | – | – | – | – | – |
| 15– 20 | 1 | 6 | – | – | – | – | 7 |
| 20– 25 | 2 | 6 | – | – | – | – | 8 |
| 25– 30 | 1 | 4 | – | 1 | – | – | 6 |
| 30– 35 | 9 | 2 | – | 4 | – | – | 15 |
| 35– 40 | 3 | – | 2 | 1 | 1 | 2 | 9 |
| 40– 45 | 2 | – | 2 | 1 | 2 | 3 | 10 |
| 45– 50 | – | – | 1 | 1 | – | 1 | 3 |
| 50– 55 | 4 | – | – | 1 | 1 | – | 6 |
| 55– 60 | – | – | 1 | – | – | – | 1 |
| 60– 65 | – | – | – | 2 | 3 | 2 | 7 |
| 65– 70 | – | 1 | 2 | – | – | – | 3 |
| 70– 75 | – | – | 1 | 1 | – | – | 2 |
| 75– 80 | – | – | – | – | – | – | – |
| 80– 85 | – | – | 2 | – | – | – | 2 |
| 85– 90 | – | – | – | – | 1 | – | 1 |
| 90– 95 | – | – | – | – | – | – | – |
| 95–100 | – | – | – | – | – | – | – |
| 100–105 | – | – | 2 | – | – | – | 2 |
| 105–110 | – | – | – | 1 | – | – | 1 |
| Totals | 22 | 20 | 13 | 13 | 8 | 8 | 84 |
| Average ratio | 33.1 | 20.4 | 60.1 | 44.3 | 53.7 | 46.9 | 36.8 |

In order to determine the reason for this tendency on the part of assessors to over-value farms in the low value groups as compared with those in the higher limits, a study was made of the extent to which certain factors affecting the value of property are considered by assessors. Factors studied included size of farm, value per arpent, and the relative value of buildings.

In considering the relation of size of farm to accuracy of assessment, it was found that farms of different size were assessed at substantially the same percentage of their estimated value (Table 4).

TABLE 3.—RELATION OF VALUE OF FARM TO EQUALITY OF ASSESSMENT

| Value of farm | Number of farms | Average ratio of assessed to estimated value |
|---|---|---|
| $ | | |
| 0–10,000 | 42 | 48.2 |
| 10,000–20,000 | 23 | 37.7 |
| 20,000 and over | 19 | 30.1 |
| All farms | 84 | 36.8 |

TABLE 4.—RELATION OF SIZE OF FARMS TO EQUALITY OF ASSESSMENT

| Size of farm (arpents) | Number of farms | Average ratio of assessed to estimated value |
|---|---|---|
| Under 100 | 36 | 37.3 |
| 100 – 200 | 33 | 36.0 |
| 200 and over | 15 | 37.3 |
| All farms | 84 | 36.8 |

A study of the relation of the "per arpent" value of farm property to the accuracy of assessment, however, indicates that while farms valued at less than $100 per arpent are assessed on the average at over 48% of their estimated value, those valued at $150 or over were assessed at 32% (Table (5). That is, farms having a low "per arpent" value are over-assessed as compared with those having a high "per arpent" value due to the fact that the assessor apparently does not give sufficient consideration to the "quality" aspect of a farm in making his assessment. As a result of this, a highly productive farm is often assessed at a lower percentage of its full value than one the productivity of which is relatively low.

The influence of the relative value of buildings and improvements on the accuracy of assessment is presented in Table 6. While farms on which buildings made up less than 20% of the value of the farm were assessed at 29% of their estimated value, those on which buildings accounted for over 60% of the value of real estate had an assessment ratio of 48%. In appraising a farm, therefore, the assessor apparently gives undue weight to buildings with the result that a poor farm which is well equipped in this respect may be assessed much higher than a more productive one, having less pretentious buildings.

TABLE 5.—RELATION OF THE "PER ARPENT" VALUE OF REAL ESTATE TO EQUALITY OF ASSESSMENT

| Estimated value of real estate per arpent | Number of farms | Average ratio of assessed to estimated value |
|---|---|---|
| $ | | |
| Under 100 | 36 | 48.2 |
| 100 – 150 | 11 | 35.9 |
| 150 and over | 37 | 32.1 |
| All farms | 84 | 36.8 |

TABLE 6.—RELATION OF THE PROPORTION WHICH VALUE OF BUILDING IS OF VALUE OF REAL ESTATE TO EQUALITY OF ASSESSMENT

| Value of buildings expressed as a percentage of value of real estate | Number of farms | Average ratio of assessed to estimated value |
|---|---|---|
| Under 20 | 7 | 29.0 |
| 20 – 40 | 38 | 38.3 |
| 40 – 60 | 32 | 36.4 |
| 60 and over | 7 | 48.4 |
| All farms | 84 | 36.8 |

From the foregoing, it is evident that considerable inaccuracy exists in the assessment of farm property in the Province of Quebec with the result that low-valued farms are over-assessed relative to those of higher value. Two of the principal causes of this inaccuracy of assessment were found to be the tendency on the part of the assessor to give insufficient consideration to the "quality" aspect of a farm and to place undue emphasis on the presence of buildings in appraising a farm for assessment purposes. A similar tendency was found to exist in the Province of Ontario.

## AGRICULTURAL MARKETING RESEARCH

W. C. Hopper[1]

One of the primary objects of agricultural marketing research is to obtain facts concerning demand which will lead to increased returns to producers of agricultural commodities. Another is to obtain information which will reveal methods of reducing the spread between producer and consumer prices.

In recent years much emphasis has been placed on the need for better and cheaper methods of distribution but before much can be accomplished in their improvement, facts respecting present distribution methods and costs must be obtained, tabulated and analysed. There are different ways of approaching a study of marketing agricultural products. One of these is the commodity approach. The marketing problems of farmers, however, vary not only with the commodity but also with distance from market, facilities for marketing and methods of marketing. The marketing problems of the farmer in Northern Ontario, for example, are quite different from those of the wheat farmer of the Prairies, the potato farmer in the Maritime Provinces and the fruit grower of Ontario and British Columbia.

Many farmers who, formerly, were interested primarily in production are beginning to realize that the demand for the product which they have to sell is as important in determining the price as the supply of that product.

A comprehensive study of the marketing of any particular commodity would involve the gathering of information of the whole process of distribution of that product from the producer to the consumer. Such a study would include investigation with respect to the methods and practices of those engaged in marketing, the costs of preparation and transportation, the facilities for handling at the farm, at the country point and at the terminal, auction or public market, wholesaling and retailing costs and the many aspects of the demand or preferences of the ultimate consumer. Such a comprehensive investigation might also include a study of the relations of quality or grade to the price obtained by the producer, the country buyer, the wholesaler and the retailer.

There are certain more or less basic agricultural products produced in Canada which are as good or better in quality than similar products produced in other countries. There are certain agricultural products which, because of the suitability of the Canadian climate and soil are produced at a lower cost than similar products can be produced in other countries. Amongst these products might be included apples, potatoes, bacon, cheese, wheat, barley, poultry products, alfalfa seed, and so forth. While the major part of our farm products are consumed at home and it is domestic marketing that requires the most intensive study, nevertheless, a study of the demand for such commodities in countries other than Canada should be of distinct advantage to the Canadian producer as well as to the nation as a whole. That portion of the product which is exported may determine the price for all the product sold at home and abroad. In the nature of *definite marketing research*, very little study has been devoted to the obtaining of facts on consumer preferences and competition with other commodities in overseas markets with a view to expanding the sale of our export products in countries which now use but small quantities of these commodities.

***Reducing the Cost of Marketing.***—Efforts to decrease the costs of marketing and reduce the spread between consumer and the producer prices so that farmers may obtain a larger share of the consumer's dollar, cannot be very successful without a knowledge of the existing marketing costs.

One of the largest items in the costs of getting farm products to market is that of transportation. The use of the motor-truck has in recent years helped to reduce the cost of transporting certain farm commodities to market. Very little study, however, has been given to cost of operating motor-trucks. Farmers sometimes wonder if it will pay them to purchase a motor-truck or to have the product which they have to

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market, handled by hired truckers. Little is known about the fairness of the rates charged by truckers and little has been done to regulate the movement of farm products by trucks in order to avoid market "gluts" and "famines." Many of our present marketing facilities are uneconomic and inadequate. With the rapid growth of motor-truck distribution, facilities for handling farm produce in our cities have not been developed to meet the needs of this new method of transportation. New methods of retailing farm products in the city and at the roadside have come about in recent years. These changes in transportation and in methods of handling farm products should be studied with a view to modernizing marketing facilities in order to reduce marketing costs. When farm prices fall, marketing costs tend to remain high, and a wide margin between the producer and the consumer prices exists. In many cases inefficiency in the marketing system rather than excessive profits in distribution are the cause of these wide margins. Studies relating to the costs of grading, packaging, processing, handling, storing, wholesaling and retailing farm commodities should reveal facts which would aid in promoting more efficient marketing.

***Studies of Consumer Demand.***—Recognizing that the ultimate end of all production is consumption leads to the conclusion that studies of the many aspects of consumer demand for any particular commodity at home and abroad will reveal ways of increasing consumer demand for that commodity. Studies of the demand of consumers with different incomes, of different nationalities and in different locations with respect to the quality, grade, size and other characteristics of the commodity and of the uses made of that commodity in different households, should help farmers to decide the kind of product to produce if they wish to meet the needs of the consumers. Studies relating to the style and size of the package in which the commodity is marketed and the methods of retailing which will reach the largest number of consumers, should help farmers to decide how they should market the commodity. A knowledge of the kind of product which meets the desires of the majority of consumers and the marketing of that product in the manner best adapted to the need of the buyers are of greatest importance to producers of every class of commodity, whether the producer be a farmer, gardener, fruit grower, poultryman, publisher, builder or manufacturer.

Producers of many kinds of manufactured products are finding it to their advantage to make a careful study of the use by the consumers of the commodity they sell. An interesting example of the use of marketing research in business is given in the book entitled Marketing Research Technique by Percival White. The author states that important decisions in business are surprisingly easy to make if all the facts are known. The Parker Pen Company believed that the public would purchase coloured fountain pens and also large-sized pens. Should such pens be produced and offered to the public? If a wrong decision were made, the results might be very costly. Users of fountain pens were approached for information on the subject and the consensus of the opinion was that coloured and large-sized pens were desirable and would be saleable. A comparatively small number of such pens were then made for use in trial markets. As these experimental sales were successful, widespread distribution was then attempted. The result was very satisfactory. The Company, however, might have been wrong in its original belief, and if it had not first used field research and trial sales, might have plunged into a disastrous attempt to give the new product nation-wide distribution.

***Method of Conducting Research Studies.***—Research calls for the gathering of facts in an impartial manner. The scientific method is the same whether applied to physics, biology, chemistry or marketing. It begins with the gathering of facts, continues with the registration and measurement of the data obtained, is followed by tabulation and charting of the information, and finally the drawing of conclusions. There are many different ways employed to obtain the facts. The examination and the extraction of the data from existing books and records, personal interviews, mail questionnaires and the actual recording of the necessary data while the process of

marketing being studied is in progress, are some of the methods which are employed to obtain the facts needed. Sometimes these data may be supplemented by statistical information which has already been gathered and tabulated by others.

*Marketing Research and the Individual Farmer*.—How will the individual farmer benefit by marketing research? An apple producer, for example, may have several alternatives from which to select his method of sale. The country dealer or shipper, the commission merchant in the city, the trucker-dealer who buys outright at the farm, the nearest public market, the roadside market, the local store, the local co-operative association and the exporter, might constitute the outlets for the apples which this particular farmer produces. Marketing research would help this producer to select the method of sale which has returned to producers in his community the higher average price for apples over a period of years. The location of the farm with respect to consuming centres, public markets and good highways, would, of course, influence the price obtained from these various agencies. Marketing studies to determine the grade, the variety or varieties, the size and type of containers which command the highest prices from the jobber, the retailer and the consumer, would be of vital interest to an individual farmer.

In addition to our domestic market for apples, we have an export market. Studies of the varieties, the size, the colour, the grade and the size and type of container, which best meet the requirements of the fruit trade and the consumers in the United Kingdom, would be very useful to individual Canadian fruit growers. Studies of approved methods of ocean shipments and of the manner of selling competing fruits, would, if properly made, yield good returns for the time and money spent on such investigations.

It was found that the most important factor lowering the price of Maine potatoes in large city markets were broken and injured tubers. Injuries of this kind can be controlled by careful production and harvesting methods but it was necessary to carry on marketing studies to show the importance of this price limiting factor.

Marketing studies have shown that some farmers regularly obtain better prices than others. Careful analysis of the product, the package, the variety, the method of shipment, the method of harvest, the kind of seed sown, the cultural methods used and the type of soil in which the product was grown by the farmer who receives the higher prices, would be of great help to those farmers who always receive the lower prices for the same commodity. One of the outstanding functions of marketing studies is to learn what, where, how and when to produce various kinds of farm commodities if the highest possible returns are to be obtained from their sale.

There are definite principles underlying the marketing of farm commodities as there are underlying their production but these marketing principles can only be determined after the facts have been obtained and analysed.

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C. M. Collins, Agricultural Representative for Annapolis County, Nova Scotia, is the author of a bulletin entitled "A Study in Apple Returns" which has been published by the Nova Scotia Department of Agriculture. One of the important results reported was that "The four-year weighted average warehouse price for ten varieties of apples of all grades and sizes varied in warehouse records examined by as much as 41 cents per barrel. In other words one warehouse packing out 33,746 barrels of these ten varieties over the four years, distributed $13,835 more to its members during that period, than it would, had its price been on a level with the lowest warehouse."

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C. S. Orwin, Agricultural Economics Research Institute, Oxford University, writing in the April issue of "The Scottish Journal of Agriculture" states "It is at once apparent that the item of labour in the total cost of the product would be very much higher in British agriculture, if farming in this country were conducted under a system of labour organization similar to that in competing countries, and it follows that only by the adoption of other methods of management designed to raise the efficiency of the labour employed can the British farmer expect to maintain his position in an open market."

# FINANCIAL STATEMENTS[1]

W. F. Chown[2]

The purpose of accounting is to build up a record of business transactions from which statements can be prepared at any time to show the actual financial position of the business and the profit or loss to the owner. Accounting is an art, not an exact science, and some knowledge of the principles involved and terminology employed should be of value in preparing simple financial statements and in the interpretation of the more difficult ones.

***Description of Statements in Common Use.***—The Statement of Assets and Liabilities is prepared at the beginning of any business enterprise or at the installation of its first systematic accounts, and thereafter at the end of each financial period or at any time special circumstances may demand. It is designed to show the financial position of a business at a given time. When drawn up in account form, the Assets are ranged upon the left-hand side and the Liabilities upon the right. The Excess of Assets over Liabilities represents the net worth of the business. During the period of operations, changes occur from day to day in the value of Assets, Liabilities and Net Worth. The profit or loss for any period may be determined by comparing such statements prepared at the beginning and end of the period. Subject to adjustment for additions or withdrawals of capital, an increase in the value of Net Worth represents a profit, and a decrease, a loss. Such a comparison determines the amount of profit or loss, but does not explain it.

The Statement of Income and Expenditure is prepared at the end of any financial period to explain as fully as may be needed the manner in which the profits have been earned or the losses incurred. When drawn up in account form, the various classes of income are ranged on the right-hand side and the various classes of expenditure on the left. An Excess of Income over Expenditure is a profit, and an Excess of Expenditure over Income is a loss.

The Balance Sheet is a statement of assets and liabilities prepared from books kept by double entry, whereas a Statement of Assets and Liabilities may be prepared from single entry records, estimates, appraisals or any method except that employed in double entry bookkeeping. The Profit and Loss Account is a statement of income and expenditure prepared, like the Balance Sheet, from books kept by double entry.

***The Statement of Assets and Liabilities.***—This Statement is a necessary basis for the installation of accounting records and also it is the necessary basis for all loans. To the prospective lender, it serves two main purposes: (1) basis of analysis for short term credit; and (2) basis of analysis for long term credit; and will be reviewed differently according to the term of the prospective loan.

***Classification of Assets and Liabilities.***—The proper classification, grouping and valuation of Assets and Liabilities are the prime requisites.

Current Assets include cash and those assets which will be converted into cash in the ordinary course of the business, e.g. notes and accounts receivable, produce or live stock intended for sale by a farmer, or butter on hand in a creamery. Fixed Assets are those of a permanent nature purchased or acquired for the purpose of earning income and not for sale, e.g. land, buildings, machinery, the herd of a dairy farmer. Other Assets may include deferred items, such as supplies or seed on hand, not for sale; prepaid items, such as insurance or rent, the value of which has not yet been consumed; and investments that will continue to be held while the business remains a "going concern."

Current Liabilities are the debts due at the date of the Statement or that will be presently payable, e.g. bank loans, accounts payable, machinery and other notes coming due during the current year, accrued wages or taxes—in short, those items that will be payable out of current funds. Fixed Liabilities are long term debts, the payment of which is deferred to a definite future time, e.g. mortgages. The Excess of

[1] To be continued.

[2] Accountant Examiner, Economics Branch, Department of Agriculture, Ottawa.

Assets over Liabilities shows the net worth of the business to its owner or owners. It consists of the original capital, plus additions of capital or earnings, less withdrawals of capital or operating losses incurred.

***Valuation of Assets.***—To the banker reviewing a statement for the purpose of determining whether an extension of credit is advisable or not, the current assets and liabilities will be of chief interest. These are the resources from which he may expect to receive repayment, set off against those obligations that must be paid in priority to this loan. This group of assets, then, should be valued at their realizable value. The usual rule in valuing merchandise inventory is "at cost or market, whichever is lower." In farm work, because the cost is not usually known, it is reasonable to value produce and live stock held for sale at a fair market value on the farm.

There are several bases on which fixed assets may be valued, but the conventional way is at cost, less depreciation to date. Land, properly worked, does not depreciate; buildings and fences depreciate at from 2–4% per year; machinery at approximately 10% per year. Horses, dairy cattle and beef breeding stock should be valued individually. Their value will increase to maturity and then will have to be reduced because of depreciation. Be conservative in this and all other valuations. The valuation of fixed assets and particularly land, buildings and machinery does not necessarily coincide with and may differ widely from present realizable value or from present replacement value; this section is somewhat historical in character, showing the cost of the assets less the value estimated to have been consumed to date and actually charged to operations.

Other Assets may properly be valued at cost, or, if that is not known, present market value or at the remaining unconsumed value in the case of prepaid insurance.

***Illustration.***—Statements I and II below illustrate the greater clarity that is achieved by a proper grouping.

I

THOMAS BROWN

STATEMENT OF ASSETS AND LIABILITIES

March 31, 1935

| ASSETS | | LIABILITIES | |
|---|---|---|---|
| Land and buildings | $ 9,600.00 | Machinery note | $ 80.00 |
| Feed and seed | 410.00 | Mortgage and interest | 4,240.00 |
| Machinery and equipment | 900.00 | Accounts payable | 100.00 |
| Live stock | 1,785.00 | Excess Assets over Liabilities | 8,636.50 |
| Cash and bank | 114.50 | | |
| Insurance prepaid | 65.00 | | |
| Milk cheque | 182.00 | | |
| | $13,056.50 | | $13,056.50 |

***Results Obtained by Re-arrangement.***—From Statement II, it is readily apparent that obligations amounting to $420.00 are presently payable, and that there are on hand cash and other resources that will soon be converted into cash, amounting to $581.50, leaving $161.50 free for running expenses. Prepaid expense items to the value of $375.00 are also shown. With these facts, and some additional information with respect to prospective earnings and expenses, it should be possible to determine the expediency of a loan.

The original cost of the Fixed Assets and the provision for depreciation to date are plainly shown so that the reader is in a position to judge of the adequacy of this provision. The mortgage of $4,000.00 is set opposite the real estate by which it is secured. It is evident that Net Worth is represented to the extent of $8,100.00 by an investment in Fixed Assets.

In statement I above, these facts are obscure whereas in statement II, they are either obvious or can be easily deduced. The same valuations have been used in both statements so that the improvement as a means of giving information has been achieved by a rearrangement of the same essential data.

II

THOMAS BROWN

STATEMENT OF ASSETS AND LIABILITIES

March 31, 1935

ASSETS

| | | | |
|---|---|---|---|
| Curren Assets:— | | | |
| Cash on hand and in bank | | $ 114.50 | |
| Milk cheque receivable | | 182.00 | |
| Live stock for sale | | 185.00 | |
| Seed grain for sale | | 100.00 | |
| Total Current Assets | | | $ 581.50 |
| Fixed Assets:— | | | |
| Land | | $ 6,000.00 | |
| Buildings | $ 6,000.00 | | |
| *deduct*, provision for depreciation | 2,400.00 | 3,600.00 | |
| Farm machinery and equipment | $ 1,800.00 | | |
| *deduct*, provision for depreciation | 900.00 | 900.00 | |
| Dairy cattle | | 1,000 00 | |
| Horses | | 600.00 | |
| Total Fixed Assets | | | 12,100.00 |
| Other Assets:— | | | |
| Feed and seed on hand | | $ 310.00 | |
| Insurance prepaid | | 65.00 | |
| Total Other Assets | | | 375.00 |
| Total Assets | | | $13,056.50 |

LIABILITIES

| | | |
|---|---|---|
| Current Liabilities:— | | |
| Accounts payable | $ 100.00 | |
| Mortgage interest | 240.00 | |
| Machinery note | 80.00 | |
| Total Current Liabilities | | $ 420.00 |
| Fixed Liabilities:— | | |
| Mortgage at 6% due 1939 | | 4,000.00 |
| Total Liabilities | | $ 4,420.00 |
| Net Worth:— | | |
| Excess Assets over Liabilities | | 8,636.50 |
| Total Liabilities and Net Worth | | $ 13,056.50 |

## AMENDMENTS TO THE CANADIAN FARM LOAN ACT, 1935

The Canadian Farm Loan Act of 1927 amended by the Parliament of Canada in 1934,[1] was radically modified by the Canadian Farm Loan Act Amendment Act, 1935.

***Canadian Farm Loan Board.***—Under the original act, the Board set-up in 1929 consisted of four members: the Minister of Finance was ex officio chairman of the Board and the Commissioner the chief executive officer. By the terms of the amending legislation, 1935, the Board shall consist of not less than three, nor more than five members, and the Commissioner will be Chairman. The Deputy Minister of Finance or the Comptroller of the Department of Finance shall be one of the members of the Board.

The Advisory Council to the Board consisting of the Provincial Treasurer of each Province of Canada in which a provincial Board was organised, and the chief executive officer of each provincial board has been abolished, and the Board may appoint for any province or for any two or more provinces in which it operates, a chief executive officer to have charge of the operations of the Board in such province or provinces. This officer will, upon appointment, exercise all the powers and duties conferred upon him by the Board. A local loan advisory board of not more than three members may be appointed by the Board and the chief executive officer is ex officio-member and chairman of it.

***Capital Requirements.***—Under the Act of 1927, the Government of Canada was authorized to subscribe initial capital to an amount not exceeding $5,000,000 for purposes of the Board. For a period of three years this initial capital was free from interest after which it drew 5% per annum and was repayable out of earnings of the Board after providing a reserve fund at least equal to the total repayments including the repayment then proposed to be made. In addition to this source of capital, the Board was authorized to issue capital stock of one dollar each. The Federal Government and the Government of each province in which loans were made were both required to subscribe for capital stock to an amount equal to 5% of the total amount of principal outstanding on loans made in such province by the Board. Each borrower was also required to subscribe to the capital stock to an amount equal to 5% of the sum borrowed by him.

This section of the Act has been amended in order to permit the Government to fix the rate of interest on initial capital advances and to eliminate the requirements for the purchase of capital stock in the Board by provincial governments and borrowers. The Government of Canada will provide the Board with initial capital to an amount not exceeding $5,000,000 on the same conditions as previously set up, that is free from interest charges for a period of three years after which time interest shall be paid at such rate as the Governor in Council shall direct instead of five per cent per annum as stated in the Act of 1927. The Board shall annually carry to reserve fund 25% of the net earnings of the Board until it equals 25% of the paid capital stock of the Board and thereafter at least 10% of the net earnings.

The Minister of Finance may purchase at a price not exceeding the par value, the capital stock already subscribed for by the provinces. The Board may also retire the outstanding capital stock subscribed by a borrower under the Act, by crediting the amount of the par value of such stock as a payment upon his loan and the borrower ceases to be a stockholder of the Board.

The outstanding Farm Loan bonds shall not exceed at any time twenty times the paid-up capital stock subscribed for by the *Government of Canada* instead of the *borrowers* as provided in the Act of 1927.

***Purchase of Bonds by Minister.***—The Minister of Finance may purchase from time to time on behalf of the Dominion of Canada, bonds issued by the Board to an amount not exceeding fifty million dollars at any one time, and the Governor

[1] See Economic Annalist, Vol. IV, No. 3, pp. 43-45.

in Council may further authorize the guarantee of the principal and interest of Farm Loan bonds to the amount of forty million dollars. Since an amount of $10,000,000 has already been loaned to farmers, the Board will have $80,000,000 available for new loans.

***Loans.***—Before an applicant can have his application considered by the Board, it is necessary that he come within the definition of farmer, which, under the Act means: A person whose principal occupation consists of farming which includes stock raising, dairying and the tillage of the soil.

Loans may be made only to farmers actually engaged or shortly to become engaged in the cultivation of the farm mortgaged and whose experience, ability and character are such as to warrant the belief that the farm to be mortgaged will be successfully cultivated, provided that no loan shall be made on the security of unimproved land except for the purpose of making improvements on it.

***Loans on First Mortgages.***—Under the Act of 1927 no loans were granted in excess of 50% of the Board's appraised value of the land and 20% of the value of buildings to a maximum loan of $10,000. The maximum amount of a loan was reduced to $7,500 by the amending legislation of 1934 and to $5,000 by that of 1935. The basis of valuation, however, has been changed in 1935 and loans shall be made only where the Board can hold first mortgages on farm land up to 50% of the Board's appraised value of land and buildings. The interest rate on such loans has been fixed at 5% per annum.

The proceeds of the loan may be used for the following purposes: to purchase farm land, fertilizers, seed, live stock, tools, machinery and any implements and equipment necessary to the proper operation of the farm mortgaged; to erect farm buildings or to clear, drain, fence or make any other permanent improvement tending to increase the productive value of the land; to discharge liabilities already accumulated; or for any other purposes which in the judgment of the Board may be reasonably considered as improving the value of the land for agricultural purposes.

***Loans on Second Mortgages.***—In any case where the Board granted a loan on the security of a first mortgage and where such a loan will not be sufficient to discharge the indebtedness of the farmer to provide for all his reasonable and necessary requirements a further loan of $1,000 may be secured on the security of a second mortgage for a period of not more than six years on farm lands in the provinces where chattel security may be taken by the Board on live stock and other personal property. In such provinces, however, the aggregate loan shall not exceed two-thirds of the appraised value of land and buildings given as security and, in any province where chattel security may not be taken, only 60% of the value of land and buildings. A loan granted on second mortgage cannot exceed one-half the amount advanced on the security of the first mortgage and in any case, the maximum aggregate loan which may be made to a farmer is $6,000. The interest rate on loans made on a second mortgage shall not exceed the current rate charged in respect of first mortgage loans by more than 1% per annum.

***Repayment of Loans.***—By the terms of the amending legislation, every loan is repayable upon such terms and within such periods not in excess of twenty-five years as the Board may prescribe. However, all loans repayable over a period in excess of five years shall be paid in equal annual or semi-annual instalments of principal and interest. The rate of interest to be paid by borrowers on defaulted payments and arrears in taxes and other charges assumed by the Board has been fixed at 5½% for the time being and shall not exceed 8% per annum.

***Relationship to Farmers' Creditors Arrangement Act, 1934.***—The purpose of these amendments to the Farm Loan Act is to provide farm mortgage credit at reasonable rate to farmers particularly when the result will be the consolidation of their indebtedness under the provisions of the Farmers' Creditors Arrangement Act or otherwise.

Whenever a proposal for a composition, extension or scheme of arrangement made under the Arrangement Act has been duly approved, the holder of a mortgage may secure from the Farm Loan Board a loan not exceeding one-quarter of the principal amount of the mortgage assigned or hypothecated, for a period of one year with possible extension of time for repayment of such loan upon approval of the Board. The proceeds of this loan, however, have to be passed to the farmer for the proper operation of the farm covered by the first mortgage. The rate of interest on such loans shall not be in excess of that payable on the mortgage assigned or hypothecated and in no case more than 1% in excess of the rate charged the mortgagee by the Board.

***Provincial Legislation.***—The amending legislation completely eliminates the principle of dual control as between the provinces and the Dominion. Administration will now be entirely and directly in the control of the Canadian Farm Loan Board, which will be able to make loans in all provinces instead of, as previously, only in those provinces which passed the necessary legislation required by the Dominion statute.

In 1931 the Quebec Legislature enacted legislation empowering the Provincial Government to contribute to the interest payable by borrowers in the province of Quebec up to 1½%, thus reducing to 5% the rate of interest on loans granted by the Canadian Farm Loan Board. In 1935 the Quebec Legislature amended this legislation in order that the rate of interest payable on farm loans by Quebec borrowers be not more than 3%.

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The Eleventh American Institute of Co-operation will be held at Cornell University, July 15–20. The Institute will emphasize instruction in co-operation: "It will be more of an instructional character with closely co-ordinated lectures thoroughly explaining various aspects of the business problems of agricultural co-operatives. These lecture courses will be supplemented by intensive conferences developing more detailed aspects of the various problems coming before the Institute" said C. W. Holman, Secretary of the Institute in a preliminary announcement.

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Nearly 100 farmers are completing cost account records in co-operation with the Department of Agricultural Economics and Farm Management, Cornell University. In the past twenty years, operators of farms, on which cost accounts have been kept, have obtained labour incomes averaging $634. For the seven-year period 1914 to 1920, a period of high prices, incomes averaged $1,241. From 1931 to 1933, when prices were very low, labour incomes averaged minus $811, whereas during the period 1921–30, the average was $644. This was a period of fairly stable prices.

## ECONOMIC LITERATURE

Allen, William, Hope, E. C., and Hitchcock, F. C. Bulletin 64. Studies of Probable Net Farm Revenues for the Principal Soil Types of Saskatchewan. Department of Farm Management, College of Agriculture, University of Saskatchewan, Saskatoon.

The writers of this bulletin have utilized the results of farm management surveys conducted during the past ten years in various sections of Saskatchewan to predict probable operating costs and revenues for twenty-four farms of different sizes representing the several soil types of that Province. The purpose of this report is to present conservative estimates of the costs likely to be incurred in farming in areas typical of the province and of the revenues that may be expected from farms of representative sizes in these areas during the next decade. Estimates of probable costs that may be anticipated are based upon farm survey experience with considered adjustments. Crop yields and grades are based on an average prevailing in the various areas between 1918 and 1930. The organization of the farm has been assumed to continue with little change. It is also assumed that farms of one section or less in size will be operated with horse draft power. Prices for both crops and live stock have been estimated

on the basis of the five-year average between 1910 and 1914 and adjustments for varied conditions in the different areas have been made. Farm expenses follow closely those obtaining in the regional surveys which have been completed, with modification to allow for changes in the price level. On farms of less than a section of land, no allowances have been made for operating an automobile but the expense of a driving horse has been allowed. An automobile of low value has been included as part of the standard equipment on the farms of a section or more. Living costs were considered for only a moderate standard of living and would not provide for extensive replacements of furnishings and clothing.

***Financial Summary.***—The net cash income represents the probable return to the farm operator and his family for their labour contribution (called the net income) and the non-cash items of expense that may be expected in building and equipment maintenance. On the basis of the net incomes shown for the representative farms, the maximum obligations that can be undertaken have been determined by reference to amortization tables and are presented for periods of fifteen and twenty years with interest at six and seven per cent for each of these periods.

A detailed operating statement is set forth for each type of farm which is summarized in the bulletin as presented below:—

SUMMARY OF STATEMENTS OF NET CASH INCOMES, NET INCOMES AND DEBT CARRYING CAPACITY OF FARMS INCLUDED IN BUSINESS STUDIES

| Soil type | Average yield of wheat 1918-1930 | Size of farm | | | Net cash income | Net income | Debt that can be amortized by net income at 6% in 20 years |
|---|---|---|---|---|---|---|---|
| | | Total acres | Acres of crop-land | Acres of crops | | | |
| | | | | | $ | $ | $ |
| Inferior prairie | 9.8 | 320 | 153 | 153 | −137 | −236 | Nil |
| | 9.8 | 640 | 304 | 293 | 458 | 267 | 3,062 |
| Average prairie (B) | 11.3 | 320 | 301 | 211 | 312 | 49 | 562 |
| | 11.3 | 640 | 598 | 406 | 856 | 597 | 6,848 |
| Poor prairie | 12.5 | 320 | 203 | 130 | −242 | −332 | Nil |
| | 12.5 | 640 | 397 | 257 | − 25 | −307 | Nil |
| Fair prairie | 13.1 | 320 | 242 | 167 | 137 | 4 | Nil |
| | 13.1 | 640 | 450 | 365 | 1053 | 859 | 9,852 |
| | 13.1 | 1280 | 902 | 732 | 3212 | 2374 | 27,230 |
| Average prairie (A) | 13.6 | 320 | 250 | 181 | 228 | 42 | 482 |
| | 13.6 | 640 | 485 | 356 | 985 | 703 | 8,086 |
| Fair to good southern park | 15.4 | 320 | 229 | 166 | 269 | 114 | 1,308 |
| | 15.4 | 640 | 465 | 330 | 1085 | 796 | 9,130 |
| Very good park and prairie | 16.4 | 320 | 268 | 181 | 510 | 307 | 3,521 |
| | 16.4 | 640 | 546 | 363 | 1611 | 1280 | 14,704 |
| Fair to good eastern park | 16.7 | 320 | 194 | 139 | 134 | − 10 | Nil |
| | 16.7 | 640 | 360 | 262 | 760 | 523 | 6,000 |
| Average northern park | 19.0 | 320 | 183 | 148 | 419 | 262 | 3,005 |
| | 19.0 | 640 | 303 | 230 | 805 | 547 | 6,286 |
| Best park | 19.0 | 320 | 221 | 181 | 692 | 432 | 4,955 |
| | 19.0 | 640 | 448 | 393 | 1978 | 1491 | 17,102 |
| Best prairie | 20.0 | 320 | 295 | 189 | 778 | 516 | 5,917 |
| | 20.0 | 640 | 596 | 380 | 2127 | 1588 | 18,214 |
| | 20.0 | 1280 | 1180 | 780 | 7025 | 5788 | 66,388 |

The authors point out that in this publication "many shortcomings will be apparent.

## NOTES

Thirty-eight (38) marketing schemes have been submitted to the Dominion Marketing Board for consideration. Of these, eleven (11) have been approved, and are in operation. Three were voted on and the percentage of voters favouring them was not considered sufficient by the Minister to approve them. One was not acted upon as the proposal was not considered expedient. Six (6) were returned to the petitioners; in four cases the principal market for the product to be regulated was within the province of production and, therefore, could not be considered as coming within the scope of the Act and in the other two cases, the products were not natural products as defined by the Natural Products Marketing Act. Seventeen (17) schemes are now under consideration by the Dominion Marketing Board.

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A. Fulton, Representative of the Ontario Fruit Growers' Association in Great Britain, reports that there has been a marked reduction in the number of slack barrels of apples shipped to that market during the present season. This is attributed to prompt shipment of apples from ordinary storage early in the season. During the late season, there was a higher percentage of "slacks" which is largely attributed to loose packing and failure "to plug" the barrels. A few shipments were forwarded without pads. The condition of the apples was reported to be very satisfactory.

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The general index number of prices of agricultural produce in Great Britain monthly average (1911–13 = 100) was 112 in March. This was three points below the index for February but 4 points above that for March, 1934, and 10 points higher than in March, 1933. If payments under the Wheat Act and the Cattle Emergency Act had been taken into consideration, the index would have been 119. Lower prices for liquid milk and fat cattle contributed largely to the lower index for March, 1935.

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H. R. Hare, Economics Branch, Department of Agriculture, Ottawa, is acting as Secretary of a subcommittee appointed by the National Barley Committee to study feed problems. W. R. White, of the Seed Branch who is Chairman of the Subcommittee, and Mr. Hare recently visited sections of Western Ontario in order to obtain information from feed dealers, elevator companies and farmers.

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The Secretary of the International Conference of Agricultural Economists has advised that preliminary plans are being made for the fourth conference to be held in Scotland during the late summer of 1936. Proceedings of the third conference held at Bad Eislen, Germany, will soon be available. Dr. J. F. Booth, Economics Branch, Department of Agriculture, is the Canadian correspondent to the International Conference.

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The Canadian Society of Agricultural Economics will hold its seventh annual meeting at the University of Alberta, Edmonton, in conjunction with the annual meeting of the Canadian Society of Technical Agriculturists. Sessions will be held each morning June 25th to 27th inclusive. Agricultural Policy, Farm Indebtedness, Land Appraisal, Credit, and Recent Changes in Marketing will be general topics for discussion.

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The 1935 acreage of wheat in Europe is reported to be slightly larger than last year. Winter damage has been confined to comparatively small areas but drought has affected the crop in Spain and Italy. Conditions have also been unfavourable in North Africa and production will likely be appreciably less in this area.

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A study of potato production in the Saint John Valley, New Brunswick, will be carried by the Economics Branch of the Dominion Department of Agriculture and the Department of Agriculture for New Brunswick. Field work will be commenced about the first of July.